ERCB Energy Resources Conservation Board

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Directive 050

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Drilling Waste Management

The Energy Resources Conservation Board (ERCB/Board) has approved this directive on May 2, 2012.

<original signed by>

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Chairman

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1 Introduction

The Energy Resources Conservation Board (ERCB) *Directive 050: Drilling Waste Management* is incorporated by reference into the *Oil and Gas Conservation Regulations* and sets out the requirements for the treatment and disposal of drilling waste generated in Alberta. Drilling waste is the mud and cuttings generated while

- drilling a well (including oilsands exploration wells) and
- directional drilling for the purpose of pipeline construction.

The soil endpoints for the drilling waste land disposal methods in this edition of *Directive 050* have been aligned with Alberta Environment and Water (AEW) *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010). While this will lead to better reclamation outcomes for land that is used for drilling waste disposal, industry is encouraged to develop alternatives to land disposal in support of the Alberta provincial policy of beneficial reuse of waste. This policy supports

- waste disposal to land when there are agronomic benefits, and
- the development of technology to improve waste recycling and reuse options and to reduce the volume of wastes sent for disposal (including land disposal).

1.1 Purpose

This directive is designed to

- provide the licensee of a well or pipeline with methods to manage drilling waste that are protective of the environment and harmonized with other waste management practices,
- enable sites used to manage drilling waste to be restored to equivalent land capability (see Appendix 7 for definition), and
- ensure drilling waste management practices meet ERCB requirements and environmental outcomes through monitoring and reporting.

A fundamental principle of this directive is that the proper management of drilling waste is the responsibility of the licensee of the well or pipeline.

Effective May 1, 2012, this edition of *Directive 050* supersedes the 1996 edition of *Directive 050* (formerly *Guide 050*). It also incorporates directions set out in the publications below, which are now rescinded.

- *Interim Directive (ID) 81-01: Subsurface Disposal of Drilling Fluids*
- *ID 99-5: Disposal of Drilling Waste Associated with EUB Regulated Pipeline and/or Other Oil and Gas Related Below Ground Boring Activities*
- *Informational Letter (IL) 2001-3: Management of Drilling Wastes Associated with Advanced Gel Chemical Systems*
- *Directive 045: Digital Data Submission of Drilling Waste Disposal Notification*

- Section 2.1 of *Directive 055 Addendum-2011-10-11: Interim Requirements for Aboveground Synthetically-Lined Wall Storage Systems, Updates to Liner Requirements, and Optional Diking Requirements for Single-Walled Aboveground Storage Tanks*

1.2 Requirements and Compliance Assurance

ERCB regulatory requirements are those rules that a licensee has a legal obligation to meet and against which the ERCB may take enforcement action in cases of noncompliance. ERCB requirements and recommendations are numbered sequentially within each section and subsection throughout *Directive 050*. "Must" indicates a requirement and "should," "expect," and "recommends" indicate a recommended practice.

During audits, inspections, and investigations, noncompliance with *Directive 050* is initiated and tracked in the following ERCB compliance categories:

- drilling waste audits—*Directive 050: Drilling Waste Management*
- drilling waste inspections—*Directive 070: Drilling Waste Disposal Inspection Manual*
- oilfield waste generator audits—*Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*; *Interim Directive (ID) 2000-04: An Update to the Requirements for the Appropriate Management of Oilfield Wastes*; and *ID 99-04: Deposition of Oilfield Waste into Landfills*

The ERCB compliance assurance program is specified in *Directive 019: Compliance Assurance*. A list of risk-assessed noncompliances is available on the ERCB website at www.ercb.ca under Industry Zone: Compliance and Enforcement: Risk Assessed Noncompliance.

1.3 Jurisdictional Overview

Pursuant to the *Environmental Protection and Enhancement Act* (*EPEA*) and its regulations, AEW is responsible for developing soil and groundwater quality and remediation guidelines, setting policy for the application of risk assessments, developing and maintaining reclamation requirements for lands designated as "specified lands" in the *EPEA*, and issuing reclamation certificates. AEW has delegated authority to issue reclamation certificates for Public Lands to Alberta Sustainable Resource Development (SRD). In situations where the lands are not designated as specified lands, reclamation requirements are established by the department or agency managing the land on behalf of the provincial or federal Crown.

Pursuant to the *Oil and Gas Conservation Act* and its regulations, the ERCB is responsible for developing and maintaining requirements for the management of oilfield wastes, including drilling waste, and for ensuring that these wastes are stored, treated, and disposed of in accordance with ERCB requirements. In doing so, the ERCB must align the waste management requirements with provincial soil quality and remediation guidelines, as well as with reclamation requirements. Should AEW develop new soil quality guidelines or update existing soil remediation guidelines, licensees must adjust the endpoints specified (see Tables 3.1, 3.2, and 3.4 accordingly).

1.4 What's New in This Edition?

Various methods, set out in the 1996 edition of *Directive 050*, for applying drilling waste to land have been retained in this edition. The requirements for each method are now based on preventing the buildup of hydrocarbon and metal concentrations in the receiving soil (in

milligrams [mg] per kilogram [kg]) to concentrations that exceed Alberta soil quality and remediation guidelines. With the exception of the mix-bury-cover disposal method, nitrogen loading rates, sodium loading rates, and allowable soil electrical conductivity and sodium adsorption ratio increases have been established for each disposal method based on the receiving soil category and depth. For the mix-bury-cover disposal method, a soil endpoint concentration for nitrogen has been established in place of the nitrogen loading rate.

Drilling waste and receiving soil assessment requirements have been updated.

Attached to the methods are additional requirements for sampling the resulting soil/waste mix and verifying that guideline values for salts, hydrocarbons, and metals have not been exceeded. The post-disposal sampling requirements are based on the drilling waste quality (e.g., concentration of metals and hydrocarbons, salinity content), sodium and nitrogen loading rates, and the receiving soil category and depth.

Updates and clarification are also provided regarding

- landowner consent;
- reclamation obligations for sites used to manage drilling wastes;
- storage of drilling wastes, including specifying suitable site and soil characteristics for sump construction, and the requirements for reuse of a sump;
- management of cement returns, including storage in aboveground synthetically-lined wall storage systems (from *Directive 055-Addendum-2011-10-11*);
- management of drilling wastes from directional drilling activities for pipeline construction;
- additional requirements for landspray and landspray-while-drilling methods being conducted in winter conditions (i.e., reduced slope and preparation of disposal area);
- management of drilling wastes on forested Public Lands;
- biodegradation techniques for hydrocarbon-based or hydrocarbon-impacted drilling wastes;
- additional requirements for mix-bury-cover disposals of drilling wastes containing nitrogen; and
- notification and information-retention requirements for drilling waste disposal.

This edition of *Directive 050* also summarizes the nonland application options that licensees can use to manage drilling waste, including

- subsurface disposal of drilling waste while drilling,
- sending drilling waste to an approved waste management facility,
- thermal treatment of drilling wastes, and
- the application process to obtain approval to modify a drilling waste management method or use an alternative method.

1.5 Effective Dates

1.5.1 Implementation Dates for *Directive 050* Requirements

With the exception of the disposal of drilling wastes resulting from advanced gel chemical mud systems, the requirements in the sections listed below are effective November 1, 2012 (six months from date of publication). Drilling wastes resulting from advanced gel chemical mud systems previously required ERCB approval for land application pursuant to *IL 2001-3*; therefore, the requirements of Sections 9, 10, 12, 13, and 14 are effective immediately when using any of the subject methods to manage drilling wastes resulting from an advanced gel chemical mud system. With respect to the requirements in Section 3 to 7, and use of the subject methods in Sections 9, 10, 12, 13 and 14 for nonadvanced gel chemical drilling wastes, licensees can continue to follow the applicable requirements in the 1996 edition of *Directive 050* until November 1, 2012, but are encouraged to follow the requirements in the following sections:

- Section 3: Soil Quality and Assessment for Sites Used to Manage Drilling Waste
- Section 4: Drilling Waste Assessment
- Section 5: Analytical and Field Screening Methods
- Section 6: Storage of Drilling Waste
- Section 7: Management of Cement Returns
- Section 9: Landspray
- Section 10: Landspray While Drilling
- Section 12: Pump-off
- Section 13: Mix-Bury-Cover
- Section 14: Landspreading

The requirements in the following sections are effective immediately:

- Section 8: Drilling Wastes from Pipelines
- Section 11: Disposal onto Forested Public Lands
- Section 15: Biodegradation
- Section 16: Subsurface Disposal of Drilling Waste While Drilling
- Section 17: Sending Drilling Waste to Approved Waste Management Facilities
- Section 18: Use of Mobile Thermal Treatment Units to Manage Drilling Waste
- Section 19: Alternative Management Methods
- Section 20: Remixing a Former Drilling Waste Disposal
- Section 21: Record Keeping and Notification Requirements

1.5.2 Disclosure Date Requirements for Unreclaimed Sites Used to Manage Drilling Wastes

Sites that are used to bury cement returns or store, mix-bury-cover, landspread, or biodegrade drilling wastes are physically disturbed and are required to be reclaimed. Disclosure of unreclaimed sites is required.

1) Licensees must disclose the following by May 1 2013 (one year from date of publication) for any remote site that has

   a) a sump that contains drilling waste and for which the storage duration has exceeded 18 months of the rig release date of the first well that contributed drilling waste to the sump,

   b) been in use for more than five years as a remote sump/storage site (e.g., multiple sump/storage systems over the years),

   c) been used to biodegrade drilling waste for more than five years, and

   d) been used for disposal of cement returns where large volumes were buried or placed into a pit or pits and where the collective dimensions of the buried cement returns/pits exceed an area of 100 m^2 (i.e., about 10 m x 10 m).

   Disclosure of a remote site is not required if an approval for its extended use has been obtained from the ERCB or if the site is in the process of reclamation or has been reclaimed, as in the following situations:

   - where the site is specified lands (refer to Section 1.7 for more details) and either a reclamation certificate has been obtained or an application for reclamation certification of the site has been submitted to AEW (for private land) or SRD (for Public lands), and

   - where the reclamation process as directed by the department/agency managing nonspecified lands on behalf of the provincial or federal Crown has been engaged or completed (refer to Sections 1.6 and 1.7 for more details).

2) Licensees must submit the disclosure information through the Digital Data Submission (DDS) screen on the ERCB website at www.ercb.ca.The disclosure form is located under ERCB/Submissions/Drilling Waste Data/Submit Waste Data; select Disclosure as the Submission Type. Licensees must also retain a copy of the completed form in the well file.

   NOTE: Authorized ERCB customers require a login ID and password to access the DDS system. For help getting a login ID, contact your company's ERCB DDS administrator. If you are unable to contact your company's ERCB DDS administrator, contact DDSAdminstrator@ercb.ca.

   The ERCB will review the information and assess whether remedial measures must be implemented or, for sites that have been open for more than five years, whether specific ERCB approval for the site is required (e.g., approval for an oilfield waste management facility as described in Sections 6.6(23) and 15.2(11). Remote sites that are not disclosed and that are found after May 1, 2013 (one year from publication date), through inspections, audits, or other means will be subject to ERCB enforcement pursuant to *Directive 019*.

1.6 Landowner/Department/Agency Consent

A well site and pipeline-right-of-way require a written agreement from the landowner or from the department/agency managing the land of behalf of the provincial or federal Crown (e.g., a surface lease, a right of entry agreement, or a disposition under the *Public Lands Act*).

With the exception of burial of cement returns, additional landowner/department/agency consent is not required to manage drilling waste on the well site on which it was generated. Drilling waste from directional drilling activities for pipeline construction can be managed on the generating pipeline's pipeline-right-of-way without additional landowner/department/agency consent in situations when the surface of the right-of-way is disturbed (e.g., top soil has been removed, right-of-way is under construction or has been disturbed for pipeline work). Consent is required to

- manage drilling waste from pipeline construction activities on the associated pipeline right-of-way when the surface of the right-of-way has been restored and is being used by the landowner/department/agency;

- manage drilling waste beyond the well site or pipeline-right-of-way boundaries using the landspray, the landspray-while-drilling, disposal onto forested Public Lands, or the pump-off method;

- store, mix-bury-cover, landspread, or biodegrade (i.e., land treat or biodegrade in a contained system) drilling waste on a site remote from the well site or pipeline-right-of-way; and

- place cement returns in pits on a well site or remote drilling waste storage site when the collective area of one or more pits exceeds 4 m^2.

3) Licensees must provide a copy of a document called, *Information for Landowners on Consent for the Disposal, Treatment, or Storage of Drilling Wastes*, to the owners of any land on which licensees plan to manage drilling wastes; this includes well sites, remotes sites, and disturbed pipeline right-of-ways.

   This document and frequently asked questions on Drilling Waste Management are located on the ERCB website at www.ercb.ca under Industry Zone: Rules, Regulations, Requirements: Directives: Directive 050.

Before consenting to have the drilling waste applied to their land, some landowners/ departments/agencies may impose conditions in addition to the requirements set out in *Directive 050*. The decision regarding monitoring of additional conditions is between the landowner/department/agency and the licensee generating the drilling waste.

The following specifies the circumstances under which a landowner/department/agency can provide consent/agreement for the purpose of *Directive 050*.

Land type	Landowner/department/agency for consent/agreement
Private land	Landowner
Public Lands	SRD (through the disposition and approval process under the *Public Lands Act*)
First Nations Lands	Indian Oil and Gas Canada (IOGC) or Indian and Northern Affairs Canada (Alberta Region) must provide approval for the disposal of drilling waste on First Nation Indian Reserves; IOGC will facilitate the necessary approvals.
Métis Settlement Lands	Affected settlement council
Canadian Forces Base Suffield (wholly owned federal lands)	Department of National Defence (through consent from the base commander)
Canadian Forces Base—Area Support Unit, Wainwright (mix of federally owned and leased provincial lands)	Department of National Defence (through consent from the base commander) and SRD
Cold Lake Air Weapons Range (leased provincial lands)	Department of National Defence (through consent from the wing commander) and SRD
Canadian Forces Base Cold Lake (wholly owned federal lands)	Department of National Defence (through consent from wing commander)

1.7 Reclamation Obligations for Sites Used to Manage Drilling Waste

The methods used to store, mix-bury-cover, landspread, and biodegrade drilling waste can require extensive drilling waste management and significant land disturbance, and licensees using these methods are required to reclaim the sites affected. If these methods are used on the well site, the affected area will typically be reclaimed when the well site is reclaimed. If a remote site is used to manage the drilling waste, licensees are responsible to reclaim the remote site to equivalent land capability.

Sites included under the definition of specified lands in the *EPEA* are subject to the legislated reclamation certification process. For sites not included under the definition of specified lands, the reclamation process is through the department or agency identified in Section 1.6.

The methods used to landspray, landspray-while-drilling, and pump-off drilling waste are typically used beyond the boundaries of the well site or pipeline-right-of-way and involve limited disturbance to land. Hence, sites used to manage drilling wastes by these methods are not required to undergo the reclamation process.

The "disposal onto forested Public Lands" method is limited, by SRD, to certain types of dispositions issued under the *Public Lands Act* (refer to Section 11).

2 Scope

2.1 Overview of Drilling Waste Management Methods

The methods set out in this directive address one-time disposal or management techniques for drilling waste generated from one well, one well licensee's drilling program, or pipeline-related directional drilling (refer to Figure 2.1, Overview of drilling waste management methods).

All the methods have specific requirements and limitations, and these, as well as the characteristics of the drilling waste, need to be considered when selecting a method. The methods addressed include

- storage of drilling waste on a well site, on a pipeline right-of-way, or at a remote site;
- landspray, landspray-while-drilling, disposal onto forested Public Lands, and pump-off of drilling waste onto surface soils, typically occurring outside the well site boundaries;
- landspread and mix-bury-cover of drilling wastes into subsoils, occurring on a well site, on a pipeline-right-of-way, or at a remote site;
- biodegradation of drilling wastes, which includes land treatment or biodegradation in a contained system, occurring on a well site or at a remote site;
- subsurface disposal of drilling waste down a well that is in the process of being drilled; and
- sending drilling waste to approved waste management facilities and the use of mobile thermal treatment units to manage drilling waste, as detailed in *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry* and any subsequent updates to it, and as summarized in this edition of *Directive 050*.

Alteration of a drilling waste management method set out in this directive or use of a method not prescribed in this directive requires prior approval from the ERCB (refer to Section 19).

Drilling Waste Management Methods
Management on well site or remote site
Management on pipeline right-of-way
Management on fields and vegetated lands
Use of approved waste management facilities
landfill, waste processing biodegradation, waste cavern, waste disposal well
Subsurface disposal of drilling waste while drilling
Alternative Management Method
application and approval
Storage
Mixed-bury-cover
Landspread
Disposal onto forested Public Lands (limited to licence of occupation and mineral surface lease)
Biodegradation
land treatment contained system
Mobile thermal treatment unit
Landspray
Landspray-while-drilling
Pump-off

Figure 2.1 Overview of drilling waste management methods

3 Soil Quality and Assessment for Sites Used to Manage Drilling Waste

3.1 Soil Endpoint Requirements

Tables 3.1, 3.2, and 3.4 set out the salt, hydrocarbon, and metal endpoints for soils that have received drilling wastes. The ERCB has adopted these endpoints from the AEW *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010).

1) If AEW develops new soil quality guidelines or updates its existing soil remediation guidelines, licensees must adjust the endpoints set out in Tables 3.1, 3.2, and 3.4, accordingly.

3.2 Soil Salinity Endpoint Requirements

The criteria set out in Table 3.1 of this directive identify suitable soil horizon and rating categories for each drilling waste disposal method, as well as acceptable initial soil and final soil/waste salinity endpoints. Refer to Appendix 2 for calculations, correction factors, and soil/waste lab mixes that can help meet the salinity endpoints.

2) Licensees must sample the receiving soil of the disposal area at the soil horizon and depth appropriate for the disposal method as identified in Table 3.1, and analyze it to verify that the background soil electrical conductivity (EC) and sodium adsorption ratio (SAR) values are within the initial criteria specified in Table 3.1.

3) For each disposal method and applicable soil horizon and depth, licensees must ensure that the EC and SAR of the waste/soil mix do not exceed the allowable changes from background soil values as set out in Table 3.1.

4) Licensees must ensure that drilling waste disposals do not exceed the maximum sodium (Na) and nitrogen (N) loading rates specified in Table 3.1. The loading rates must be prorated to the actual area of land used for disposal.

There are circumstances where licensees will be required to sample the soil/waste mix within 60 days of the disposal and analyze it to verify that the endpoints set out in Table 3.1 have not been exceeded. These requirements are set out in the section specific to each disposal method.

Table 3.1 Soil salinity endpoints[1]

Disposal method	Receiving soil horizon, category[2], and limiting initial salinity criteria	Electrical conductivity (EC) changes from background soil conditions (dS/m)	Sodium adsorption ratio (SAR) changes from background soil conditions	Maximum sodium (Na) and nitrogen[3] (N) loading (kg/ha) and maximum [N] concentration (mg/kg)	Post-disposal soil sampling triggers
Pump-off	Topsoil[4] Good category EC < 2 dS/m SAR < 4	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC, but not to exceed an EC[5] of 2 dS/m	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil SAR, but not to exceed a SAR of 4	Na 250 N 25	Waste EC > 5 dS/m N loading rate > 20 kg/ha Na loading rate > 150 kg/ha
Disposal onto forested Public Lands	Topsoil Good category EC < 2 dS/m SAR < 4	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC, but not to exceed an EC[4] of 2 dS/m	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil SAR, but not to exceed a SAR of 4	Na 250 N 25	Waste EC > 8 dS/m N loading rate > 20 kg/ha Na loading rate > 150 kg/ha
Landspray, landspray-while-drilling	Topsoil Good category EC < 2 dS/m SAR < 4	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC, but not to exceed an EC[5] of 2 dS/m	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil SAR, but not to exceed a SAR of 4	Na 250 N 25	Waste EC > 10 dS/m N loading rate > 20 kg/ha Na loading rate > 150 kg/ha
Landspread, land treatment	Subsoil[6] to 1 m Good category EC < 3 dS/m SAR < 4	Soil/waste mix limited to a maximum increase of 2 units beyond background soil EC, but not to exceed an EC of 3 dS/m	Soil/waste mix limited to a maximum increase of 3 units beyond background soil SAR, but not to exceed a SAR of 6	Na 500 N 400	Landspread only, waste EC > 8 dS/m or [Na] > 2000 mg/L, or N loading rate > 300 kg/ha
Landspread, land treatment	Subsoil to 1 m Fair category EC of 3 to 5 dS/m SAR of 4 to 8	Soil/waste mix limited to a maximum increase of 1 unit beyond background soil EC	Soil/waste mix limited to a maximum increase of 2 units beyond background soil SAR	Na not applicable N 400	Landspread only, waste EC > 8 dS/m or [Na] > 2000 mg/L, or N loading rate > 300 kg/ha
Mix-bury-cover	Subsoil between 1 and 1.5 m Good or fair category EC ≤ 5 SAR ≤ 8	Soil/waste mix limited to a maximum increase of 2 units beyond background soil EC	Soil/waste mix limited to a maximum increase of 4 units beyond background soil SAR	Na not applicable [N] coarse soil[7] = 10 mg/kg or [N] fine soil[8] = 40 mg/kg	Waste EC > 10 dS/m or [Na] > 3000 mg/L , or [N] (wet weight) for coarse soil disposal ≥6 mg/kg or fine soil disposal ≥120 mg/kg
Mix-bury-cover	Subsoil 1.5 m and deeper Good, fair, poor, or unsuitable category	Soil/waste mix limited to a maximum increase of 3 units beyond background soil EC	Soil/waste mix limited to a maximum increase of 6 units beyond background soil SAR	Na not applicable [N] coarse soil[7] = 10 mg/kg or [N] fine soil[8] = 40 mg/kg	Waste EC > 10 dS/m or [Na] > 3000 mg/L, or [N] (wet weight) for coarse soil disposal ≥6 mg/kg or fine soil disposal ≥120 mg/kg

[1] Note that caution must be exercised when applying saline waste to hay and pasture land where salt-sensitive species are growing. Salt-sensitive species include, but are not limited to, red clover, alsike clover, alfalfa, and timothy. The potential for damage to vegetation is especially high when the soil is dry. Use extreme caution when conducting disposals on no-till fields in the spring prior to seeding.

[2] Receiving soil categories are defined in accordance with AEW's *Salt Contamination Assessment and Remediation Guidelines* (2001).

[3] Total mineral nitrogen (i.e., ammonia-nitrogen, nitrate-nitrogen, and nitrite-nitrogen) and the loading rate must be prorated to the actual area of land used for disposal.

[4] Topsoil is the uppermost layer(s) of soil that consists of the L, F, H, O, and/or A horizons or the depth of tillage, whichever is greater.

[5] Some plant species will be sensitive to salinity levels below 2 dS/m (e.g., flax, clover, beans, some wheat varieties, peas, some garden crops, and some forest species). Drilling waste disposal must not cause adverse effects to these species.

[6] Subsoil is the layer of soil directly below the topsoil. It consists of the B and C horizons and extends to bedrock. For salinity management, three depths are recognized: top of the subsoil to a depth of 1 m; subsoil from > 1 m to 1.5 m; and subsoil at a depth > 1.5 m.

[7] Coarse soils have a median grain size >75 microns.

[8] Fine soils have a median grain size ≤75 microns.

3.3 Soil Hydrocarbon Endpoint Requirements

Table 3.2 sets out the hydrocarbon soil quality endpoints for soils receiving drilling wastes. Endpoints are identified for coarse- and fine-grain soils for three different land uses: natural area, agricultural, and residential/parkland. Refer to Appendix 3 for guidance on predicting hydrocarbon concentrations in soil/waste mixes and the rationale for protocol revisions related to hydrocarbon endpoints. Refer to Appendix 6 for equations used to predict application rates.

5) Licensees must prevent soils that receive drilling wastes from exceeding the hydrocarbon endpoints set out in Table 3.2.

   In situations where the concentration of any of the hydrocarbon fractions (i.e., benzene, toluene, ethyl benzene, and xylene [BTEX] and hydrocarbon fractions F1 through F4) in the drilling waste exceeds the concentration listed in Table 3.3 as correlated to the specific gravity of the drilling waste, licensees will be required to sample the receiving soil/waste mix within 60 days of the disposal and analyze it to verify that the endpoints in Table 3.2 were not exceeded. Details respecting these requirements are set out in the section specific to each disposal method.

Table 3.2 Soil hydrocarbon endpoints

	Natural area land use		Agricultural land use		Residential/parkland land use	
Hydrocarbon fraction	Fine soil[1] (mg/kg)	Coarse soil[2] (mg/kg)	Fine soil (mg/kg)	Coarse soil (mg/kg)	Fine soil (mg/kg)	Coarse soil (mg/kg)
F1 (C_6-C_{10}, excluding BTEX)	210	210	210	24	210	24
F2 (>C_{10}-C_{16})	150	150	150	130	150	130
F3 (>C_{16}-C_{34})	1300	300	1300	300	1300	300
F4 (>C_{34})	5600	2800	5600	2800	5600	2800
Benzene	0.046	0.078	0.046	0.073	0.046	0.073
Toluene	0.52	0.49	0.52	0.49	0.52	0.49
Ethylbenzene	0.11	0.21	0.11	0.21	0.11	0.21
Xylenes	15	28	15	12	15	12

[1] Fine soils have a median grain size ≤75 microns.
[2] Coarse soils have a median grain size >75 microns.

Table 3.3 Hydrocarbon concentration in drilling waste

	Concentration of hydrocarbon fraction in drilling waste (wet weight mg/kg) correlated to specific gravity of drilling waste[1]							
Specific gravity (SG) of drilling waste[2]	F1	F2	F3	F4	Benzene	Toluene	Ethyl-benzene	Xylenes
1.1	104	565	1304	12169	0.20	2.13	0.48	52
1.2	99	535	1235	11529	0.19	2.02	0.45	49
1.3	94	510	1177	10989	0.18	1.92	0.43	47
1.4	90	489	1128	10525	0.17	1.84	0.41	45
1.5	87	470	1085	10123	0.17	1.77	0.40	43
1.6	84	454	1047	9771	0.16	1.71	0.38	42
1.7	81	439	1014	9461	0.16	1.66	0.37	41
1.8	79	426	984	9185	0.15	1.61	0.36	39
1.9	77	415	958	8939	0.15	1.56	0.35	38
2.0	75	405	934	8716	0.14	1.53	0.34	37
2.1	73	395	912	8516	0.14	1.49	0.33	36
2.2	71	387	893	8333	0.14	1.46	0.33	36
2.3	70	379	875	8166	0.13	1.43	0.32	35
2.4	69	372	859	8013	0.13	1.40	0.31	34
2.5	67	366	843	7873	0.13	1.38	0.31	34

[1] Calculated using Alberta Tier 1 de-minimus guideline values and a soil:waste mix ratio of 3:1.

[2] See Appendix 6, Section A6.2.1 for information on specific gravity measurement.

3.4 Soil Metal Endpoint Requirements

Table 3.4 sets out the metal soil quality endpoints for soils receiving drilling wastes. In situations where the soil/waste mix is expected to exceed the total barium value, licensees can follow AEW *Soil Remediation Guidelines for Barite* (2009) to determine if the barite guidelines can be used at a particular site. Refer to Appendix 4 for guidance predicting metal concentrations in drilling wastes and soil/waste mixes. Refer to Appendix 6 for equations used to predict application rates.

6) Licensees must prevent soils that receive drilling wastes from exceeding the metal endpoints set out in Table 3.4 for the appropriate land use.

   In situations where the concentration of any metal in the drilling waste exceeds the concentrations listed in Table 3.5 as correlated to the specific gravity of the drilling waste, licensees will be required to sample the receiving soil/waste mix within 60 days of the disposal and analyze it to verify that the endpoints in Table 3.4 were not exceeded. Details respecting these requirements are set out in the section specific to each disposal method.

Table 3.4 Soil metal endpoints—guideline values

Metal	Guideline value (mg/kg)		
	Agricultural land use	Natural area land use	Residential/parkland land use
Antimony	20	20	20
Arsenic (inorganic)	17	17	17
Barium	750	750	500
Barite-barium[1]	10 000	10 000	10 000
Beryllium	5	5	5
Boron (hot water soluble)	2	2	2
Cadmium	1.4	3.8	10
Chromium (total)	64	64	64
Chromium (hexavalent)	0.4	0.4	0.4
Cobalt	20	20	20
Copper	63	63	63
Lead	70	70	140
Mercury (inorganic)	6.6	12	6.6
Molybdenum	4	4	4
Nickel	50	50	50
Selenium	1	1	1
Silver	20	20	20
Thallium	1	1	1
Tin	5	5	5
Uranium	23	33	23
Vanadium	130	130	130
Zinc	200	200	200

[1] AEW's *Soil Remediation Guidelines for Barite* (2009) must be followed to determine if the site qualifies as a barite site. If it does not, then the 750 mg/kg total barium value applies.

Table 3.5. Metal concentration in drilling waste

	Concentration of metal in drilling waste (wet weight mg/kg) correlated to specific gravity of drilling waste[1]															
Specific gravity (SG) of drilling waste[3]	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.0**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**Background metal value used**
Metal																
Antimony	86	82	78	75	72	69	67	65	64	62	61	59	58	57	56	0.12
Arsenic	49	47	45	44	43	42	41	40	40	39	39	38	38	37	37	6
Barium	2500	2400	2304	2200	2200	2100	2000	2000	2000	1900	1900	1900	1800	1800	1800	180
Barite-Ba	43000	40500	39000	37000	36000	34000	33000	32000	31000	31000	30000	29000	29000	28000	28000	180
Beryllium	20	19	19	18	17	17	16	16	15	15	15	14	14	14	14	0.3
Boron (hot water soluble)	7.9	7.5	7.1	6.9	6.6	6.4	6.2	6.0	5.9	5.8	5.6	5.5	5.4	5.3	5.3	0.2[2]
Cadmium	5.2	5.0	4.8	4.6	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.7	3.7	3.6	3.6	0.2
Chromium (total)	200	190	180	180	170	170	170	160	160	160	150	150	150	150	150	19
Chromium (hexavalent)	1.7	1.6	1.6	1.5	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	0.002[2]
Cobalt	53	52	50	49	48	47	46	45	44	44	43	43	42	42	41	8
Copper	210	200	190	180	180	170	170	170	160	160	160	150	150	150	150	16
Lead	260	250	240	230	220	220	210	200	200	200	190	190	180	180	180	10
Mercury	29	27	26	25	24	23	22	22	21	20	20	20	19	19	19	0.03
Molybdenum	14	14	13	13	12	12	12	11	11	11	11	10	10	10	10	0.7
Nickel	130	120	120	120	110	110	110	110	110	100	100	100	100	100	100	22
Selenium	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.3	2.2	2.2	2.2	2.1	2.1	2.1	2.1	0.4
Silver	86	81	77	74	71	69	67	65	63	62	60	59	58	57	56	0.3
Thallium	3.6	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.8	2.7	2.6	2.6	2.6	2.5	2.5	0.18
Tin	16	15	15	14	14	13	13	13	13	12	12	12	12	12	11	1.4
Uranium	92	87	83	80	77	74	72	70	69	67	66	64	63	62	61	2
Vanadium	450	430	410	400	380	370	360	360	350	340	330	330	320	320	310	28
Zinc	630	600	580	560	540	530	520	510	500	490	480	470	470	460	460	58

[1] Calculated using Alberta-specific metal background values (except CCME value used for uranium), Tier 1 de-minimus guideline values, a soil:waste mix ratio of 3:1, and a soil dry bulk density (DBD) of 1.54 mg/m³.

[2] Median value used for background.

[3] Refer to Appendix 6, Section A6.2.1 for information on specific gravity.

3.5 Receiving Soil Assessment and Disclosure of Exceedance of Soil Endpoint Requirements

The application of drilling waste to soil requires assessment of the receiving soil conditions at the disposal location and the soil/waste mixing depth for the specific disposal method. Details respecting these requirements are set out in the section specific to each disposal method.

7) When assessing receiving soil conditions, licensees must ensure that each sampling site is representative of

   a) the landscape in the proposed disposal area and of the most sensitive part of the landscape (e.g., convergent footslopes and toeslopes are usually the most sensitive parts of the landscape and may have naturally higher levels of sodium and sulphate or may have concentrated parameters from previous drilling waste disposals), and

   b) any previous drilling waste disposals within the disposal area.

8) When using a field screening program to determine initial soil salinity and suitability for receipt of drilling wastes, licensees must ensure that the field screening program is supported by an ongoing quality assurance/control program as set out in Section 5.

9) When post-disposal sampling of the waste/soil mix is required, licensees must

   a) have the samples laboratory analyzed (i.e., field screening is not acceptable) following the direction set out in Section 5, and

   b) assess soil particle size and use discrete (not composite) samples of the soil or soil/waste mix when analyzing for the hydrocarbons fractions set out in Table 3.2.

10) In situations where post-disposal sample results exceed any of the soil endpoints in Tables 3.1, 3.2, or 3.4, licensees must electronically submit a notification to ERCB disclosing the exceedance as a noncompliance event. The notice of disclosure must describe the situation (i.e., the type of disposal and drilling waste and the soil endpoints that are exceeded) and contain a plan to remedy it (i.e., reduce the exceedance[s] to acceptable levels).

11) Licensees must electronically submit the notification to the ERCB in .pdf as an e-mail attachment as follows:

   a) E-mail the notification to Directive050@ercb.ca.

   b) Ensure that the attachment file name identifies it as a drilling waste disposal endpoint exceedance disclosure, contains the applicable well licence number and the unique well identifier (UWI) of the well that generated the drilling waste or to which it is linked, and is formatted as DW_License#_UWI (e.g., ExceedanceDW_0123456_00~12-14-025-12W4~0).

   c) Ensure that the subject field of the e-mail contains the file name.

   The ERCB will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliant event in accordance with *Directive 019*.

4 Drilling Waste Assessment

4.1 General Drilling Waste Sampling and Assessment

Appropriate sample collection, preservation, and storage are critical to the acquisition of the data required to assess drilling wastes. The data, which are used to determine methods for the appropriate management of drilling wastes, are only as valid as the sample collected and analyzed.

4.2 Drilling Waste Sampling Requirements

1) Where a sump or drilling waste storage system has an area less than or equal to 500 m^2, licensees must obtain a representative composite drilling waste sample comprised of equal amounts of five subsamples.

2) Where a sump or drilling waste storage system has an area greater than 500 m^2, licensees must obtain a representative composite drilling waste sample comprised of equal amounts of one subsample for each 100 m^2 to a maximum of 10 subsamples.

3) Licensees must ensure that the minimum distance at which samples are taken from the edge of a sump or drilling waste storage system is 1 m.

4) If the suction and discharge points in a sump or drilling waste storage system are identifiable, licensees must ensure one of the subsamples is taken at each point.

5) If the fluid, clear liquids, or solid phase of the drilling waste are being managed separately, licensees must obtain a representative composite sample for each phase.

6) Licensees must ensure that the subsamples are collected from the entire depth of each phase and that any hydrocarbon layer in the subsample is retained if the hydrocarbon is not being removed from the drilling waste prior to disposal.

7) If the fluid and solid phases of the sump or drilling waste storage system are being managed together, licensees must take each subsample that comprises the resprsentative composite sample from the entire depth of the fluids and solids at one time (i.e., must not be made up of individually sampled fluid or solid phases).

8) On a sketch of the sump or drilling waste storage system, licensees must identify the locations and depths of the subsamples taken to obtain the representative composite drilling waste sample.

9) Licensees must divide the representative composite drilling waste sample into containers, as appropriate, for the analysis needed to be completed to provide the data to support the method being used to manage the drilling waste.

10) If implementation of the drilling waste management method occurs 30 days after, but not more than six months after, the original sampling date, licensees must determine the pH, EC, and SAR of the drilling waste using appropriate field screening methods (refer to Section 5) to ensure the parameters are consistent with the original analysis.

11) If implementation of the drilling waste management method occurs six months after the original sampling date, licensees must resample and analyze the drilling waste.

12) Immediately prior to implementing the management method, licensees must inspect the drilling waste sump or storage system to determine if materials have been added to the drilling waste.

13) If there is any evidence from the results of the field screening tests or the inspection that indicates materials may have been added to the drilling waste since the original sampling date, licensees must resample and analyze the drilling waste.

4.3 Drilling Waste Assessment and Toxicity Requirements

14) Licensees must ensure that field screening programs used to assess the applicability of a drilling waste management method are supported by an ongoing quality assurance/control program as set out in Section 5.

15) Licensees must ensure that analysis for EC, SAR (sodium, calcium, magnesium), and forms of nitrogen in

    a) oversaturated drilling waste samples is done on an as-received filtrate; clarified filtrate generated by filtration or centrifuging to pass through a Whatman No. 1 filter paper or equivalent; or

    b) undersaturated drilling wastes is done on a saturated paste extract.

    NOTE: Nitrogen analysis must include ammonia-nitrogen, nitrate-nitrogen, and nitrite-nitrogen forms.

16) Licensees must ensure that the metal- and hydrocarbon-content analyses of drilling wastes are conducted on the samples as received.

    NOTE: Screening methods can be used to determine hydrocarbon content in drilling waste samples, but to determine hydrocarbon content in soils and soil/waste mixtures, the procedures and methods referenced in AEW *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* must be used.

17) Licensees must use the luminescent bacteria toxicity test to evaluate drilling waste toxicity. The pass threshold for a drilling waste to be considered nontoxic is set at 75 per cent for an EC50(15) (i.e., a drilling waste aqueous concentration that halves the initial light output of luminescent bacteria after 15 minutes must be 75 per cent or greater). Refer to Appendix 5 for reference methods and procedures for toxicity testing using luminescent bacteria.

18) If the EC50(15) value of the toxicity test is less than 75 per cent, licensees must have a sample of the drilling waste treated with coarse activated carbon (charcoal) in a lab and then have the charcoal-treated sample tested for toxicity using luminescent bacteria (refer to Appendix 5, Section A5.2.5 for more information).

    Treatment of a drilling waste sample with charcoal is designed to identify wastes that are toxic due to their content of weakly water-soluble chemicals, such as hydrocarbons. In cases where the test is expected to show toxic effects due to the addition of hydrocarbon to the drilling waste, the initial toxicity test can be conducted on the charcoal-treated sample of drilling waste.

19) If the charcoal-treated drilling waste passes the toxicity test (EC50[15] $\geq$ 75 per cent), licensees must have the drilling waste tested for hydrocarbon content (BTEX and

hydrocarbon fractions F1 to F4; refer to Section 3.3). If the hydrocarbon analysis identifies that hydrocarbons are present and are the likely source of toxicity, diposal may proceed provided all relevant criteria for the disposal method can be met.

NOTE: Charcoal treatment is only to be done in the lab on drilling waste samples and not on the drilling waste being applied to land.

20) For drilling wastes with an original EC(50)(15) value and a charcoal treated EC(50(15) value less than 75 per cent (which indicates the presence of toxicants), licensees must

a) gather further data to determine the cause of toxicity prior to proceeding with disposal, or, alternatively

b) send the drilling waste to an approved waste management facility or manage the drilling waste according to an alternative plan that has been approved by the ERCB.

Toxicity that cannot be attributed to hydrocarbon content indicates that the drilling waste needs to be treated and retested before disposal. Toxicological information should be reviewed for all of the fluid additives/mud products used to formulate the drilling mud; where there is an absence of information for an additive/product, its contribution to toxicity cannot be ruled out. Operating practices at the well site should be reviewed to determine whether other conditions could have caused toxicity to develop (e.g., adding camp sewage or rig waste, such as chain oil, pipe dope, or rig wash, to the sump or storage system).

21) If in-field treatments are conducted (e.g., pH adjustment, aeration) to reduce drilling waste toxicity, licensees must resample and test the drilling waste to determine if it meets the toxicity requirements. Additional lab testing may be required to determine whether field treatment methods will reduce toxicity. See Figure 4.1, which outlines the decision-making process described in this section.

4.4 Generic Mud System Requirements

To help decide whether to use the landspray, landspray-while-drilling, and disposal onto forested Public Lands methods of managing drilling wastes (alleviate uncertainties about metal content and toxicity), licensees can develop a generic mud system, analyze it, and use the results to determine the applicability of each disposal method.

Licensees using the generic mud system have to follow minimum requirements.

22) Licensees must

a) develop a generic mud system that mimics the mud formulation that will be used for the drilling program (must contain the highest concentration of individual mud products/fluid additives that would be used in the mud system), and

b) test the mud system for metals (listed in Table 3.4), toxicity (luminescent bacteria), and salinity (EC, SAR, Na, NH_4-N, NO_3-N, NO_2-N).

23) Licensees must only proceed with plans to use the landspray, landspray-while-drilling, and disposal onto forested Public Lands drilling waste management methods if the generic mud system

a) passes the luminescent bacteria toxicity test,

b) contains metal concentrations that would not result in exceedances of the soil metal endpoints in Table 3.4, and

c) does not have salinities that would result in exceedances of the salinity endpoints set out in Table 3.1.

24) Licensees must re-evaluate use of the landspray, landspray-while-drilling, or disposal onto forested Public Lands method if drilling operations result in changes to the drilling mud/waste system (i.e., increase the concentration of fluid additives/mud products, add new fluid additives/mud products, or encounter a hydrocarbon flag), and only continue with use of the method if the requirements specific to it can be met.

25) Licensees must monitor changes from the generic mud system by sampling drilling waste from 5 per cent of the wells drilled as part of the drilling program, or a minimum of two wells (for small drilling programs where 5 per cent would be less than two wells) and test the samples for toxicity and metals. Disposal may proceed before the results are received if all other requirements for the landspray, landspray-while-drilling, or disposal onto forested Public Lands method are met.

26) If drilling waste sampling results identify either metal content in excess of any of the values in Table 3.5 or toxicity threshold failure, licensees must sample the disposal area (drilling waste/soil mix) and analyze the samples to determine compliance with endpoints set out in Tables 3.1, 3.2, and 3.4.

27) If disposal area sampling results identify any exceedance of the endpoints in Tables 3.1, 3.2, or 3.4, licensees must re-evaluate the appropriateness of the landspray, landspray-while-drilling, and disposal onto forested Public Lands disposal methods for the remainder of the drilling program.

NOTE: Exceedances of soil endpoints are to be disclosed to the ERCB (refer to Section 3.5).

Refer to Sections 9, 10, and 11 for additional post-disposal sampling and analysis requirements based on drilling waste salinity and hydrocarbon content.

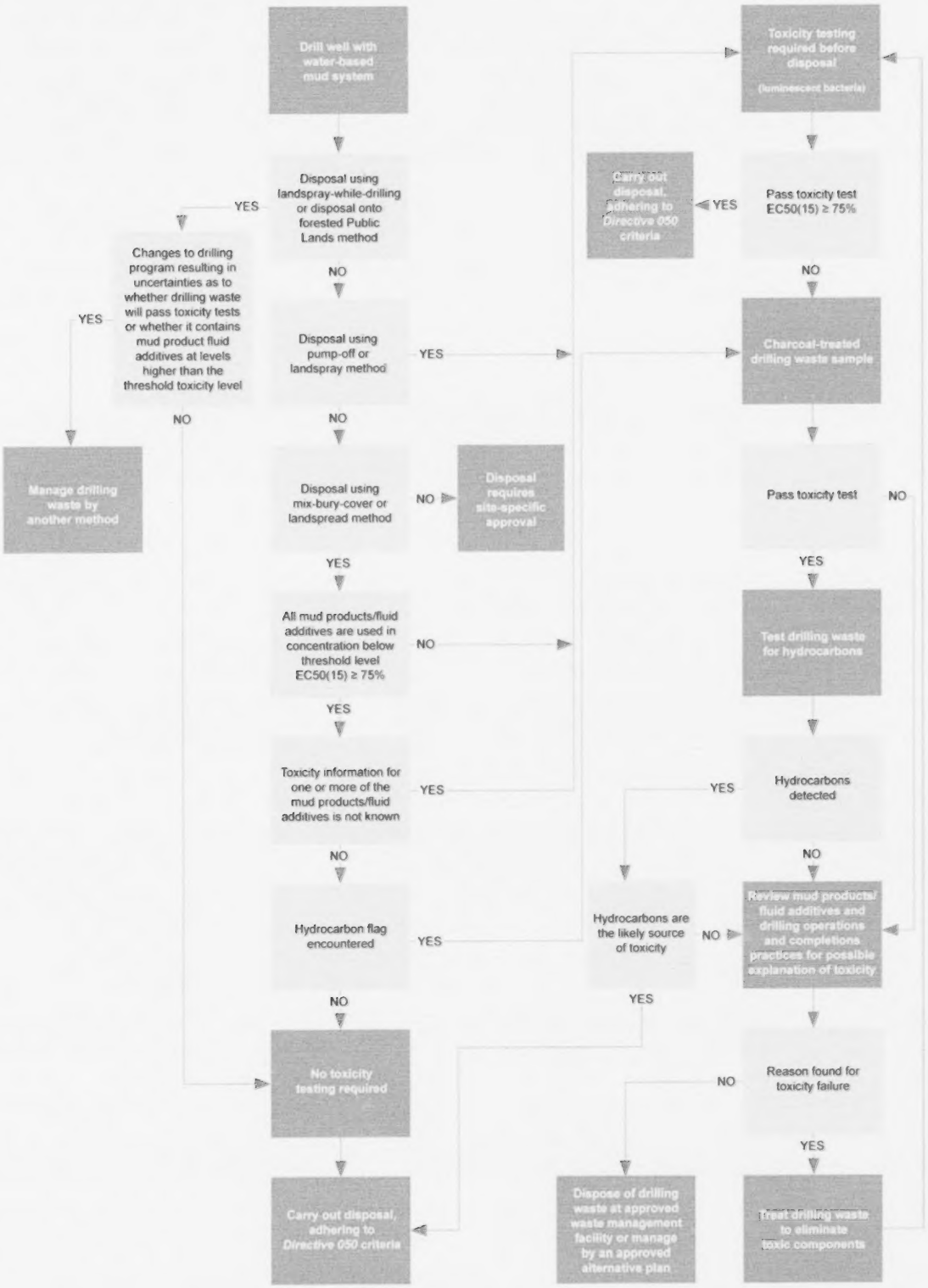

Drill well with water-based mud system
Disposal using landspray-while-drilling or disposal onto forested Public Lands method
YES
Changes to drilling program resulting in uncertainties as to whether drilling waste will pass toxicity tests or whether it contains mud product fluid additives at levels higher than the threshold toxicity level
YES
NO
Manage drilling waste by another method
NO
Disposal using pump-off or landspray method
YES
NO
Disposal using mix-bury-cover or landspread method
NO
Disposal requires site-specific approval
YES
All mud products/fluid additives are used in concentration below threshold level EC50(15) ≥ 75%
NO
YES
Toxicity information for one or more of the mud products/fluid additives is not known
YES
NO
Hydrocarbon flag encountered
YES
NO
No toxicity testing required
Carry out disposal, adhering to Directive 050 criteria
Toxicity testing required before disposal
(luminescent bacteria)
Carry out disposal, adhering to Directive 050 criteria
YES
Pass toxicity test EC50(15) ≥ 75%
NO
Charcoal-treated drilling waste sample
Pass toxicity test
NO
YES
Test drilling waste for hydrocarbons
Hydrocarbons detected
YES
NO
Hydrocarbons are the likely source of toxicity
NO
Review mud products/ fluid additives and drilling operations and completions practices for possible explanation of toxicity
YES
Reason found for toxicity failure
NO
YES
Dispose of drilling waste at approved waste management facility or manage by an approved alternative plan
Treat drilling waste to eliminate toxic components

Figure 4.1 Drilling waste toxicity assessment decision tree

4.5 Drilling Wastes Containing Radioactive Isotopes Requirements

Radioactive isotopes are sometimes added to drilling mud systems as tracers, in which case they will also be in the resulting drilling waste.

The disposal of radioactive isotopes is regulated by the Canadian Nuclear Safety Commission (CNSC) in accordance with the *Nuclear Substances and Radiation Devices Regulations*, which falls under the *Nuclear Safety Control Act*. Pursuant to Section 5.1 in the *Nuclear Substances and Radiation Devices Regulations*,

> a person may, without a license, abandon or dispose of a radioactive nuclear substance if the activity or the activity concentration of the substance does not exceed its exemption quantity, conditional clearance level, or unconditional clearance level.

Drilling wastes containing radioactive isotopes are subject to the CSNC regulation, so only those with concentrations less than the prescribed quantities can be land-applied following the methods outlined in *Directive 50*.

28) When land applying drilling waste containing radioactive isotopes following a method in *Directive 050*, licensees must

    a) ensure that the concentration of the radioactive isotope that is used is documented and retained in the well file, including any conversion factors used to demonstrate that the resulting concentration in the drilling wastes is below the prescribed limits; and

    b) disclose to relevant landowners that drilling wastes to be disposed on their land contain radioactive isotopes.

29) Should the radioactive isotope concentration within a drilling waste be subject to CNSC regulation, licensees must also ensure that the drilling waste management method complies with ERCB requirements.

    NOTE: For information on control and disposal of recirculated radioactive contaminated frac sand, refer to *Directive 58*, Section 32: Radioactive Contaminated Oilfield Wastes.

5 Analytical and Field Screening Methods

5.1 Analytical Method Requirements

Due to technical advances, many documented methods rapidly become obsolete. Consequently, a complete list of analytical protocols is not provided with this document.

1) To assess drilling wastes, soils, and soil/waste mixes, licensees must use recognized and published analytical methods, preferably ones for which Standard Council of Canada (SCC) or Canadian Association For Laboratory Accreditation (CALA) recognition has been obtained or is expected. Both SCC and CALA are full signatory members of the International Laboratory Accreditation Cooperation (ILAC). ILAC recognition requires that the accrediting body operate its accreditation program according to the international standard ISO/IEC 17011, that laboratory accreditations be based on ISO/IEC 17025, and that periodic evaluations be conducted by a team of experts.

2) When using an alternative analytical method, licensees must support its use using data that shows the method's equivalence to an appropriate accredited method.

Refer to Appendix 9 for references on analytical methods.

5.2 Field Screening Requirements

3) Licensees must limit use of field screening test methods to the assessment of

   a) the suitability of soils to receive drilling wastes;

   b) the suitability of drilling wastes to be managed by landspray-while-drilling, and disposal onto forested Public Lands; and

   c) minor treatment of drilling wastes in the field (e.g., pH adjustment).

4) Licensees must limit parameters assessed by field screening test methods to pH, EC, SAR, (magnesium [Mg], Na, calcium [Ca]), nitrogen (NH_4-N, NO_3-N, NO_2-N), and hydrocarbons (i.e., BTEX and F1, F2, F3, and F3 fractions).

5) When choosing a field screening test method, licensees must ensure that

   a) the detection range of the chosen method is appropriate for the characteristics of the wastes or receiving soils being measured and

   b) the detection limit of the test encompasses the criteria the sample is being evaluated against (e.g., for receiving soils that must have an EC below 2 dS/m, the method chosen to analyze the receiving soil sample must have a detection range below and above 2 dS/m).

6) Licensees must ensure that all field screening programs are supported by an ongoing quality assurance/quality control (QA/QC) program that includes

   a) training of field personnel on methods and instrumentation;

   b) equipment/instrument calibration and maintenance programs;

   c) documented standard operating procedures (SOPs); and

d) verification of data quality objectives (e.g., lab truthing, use of duplicates and blanks, use of analytical methods in the correct range).

7) Licensees must laboratory verify 5 per cent of field measurements and one receiving soil sample per well and

   a) if any of the laboratory results are higher than the field results, recalculate the loading rates or spread rates using the lab results.

   b) if the recalculated loading or spread rates exceed *Directive 050* soil endpoints, post-disposal sample the receiving field (soil/waste mixture).

   NOTE: Exceedance of soil endpoints are to be disclosed to the ERCB (refer to Section 3.5).

8) Licensees must ensure that the labortatories used to verify measurements from field screening programs and to analyze soil/waste mixes have QA/QC programs in place and are using analytical methods as specified in Section 5.1.

   Refer to Figure 5.1, Field QA/QC Verification Program for a summary.

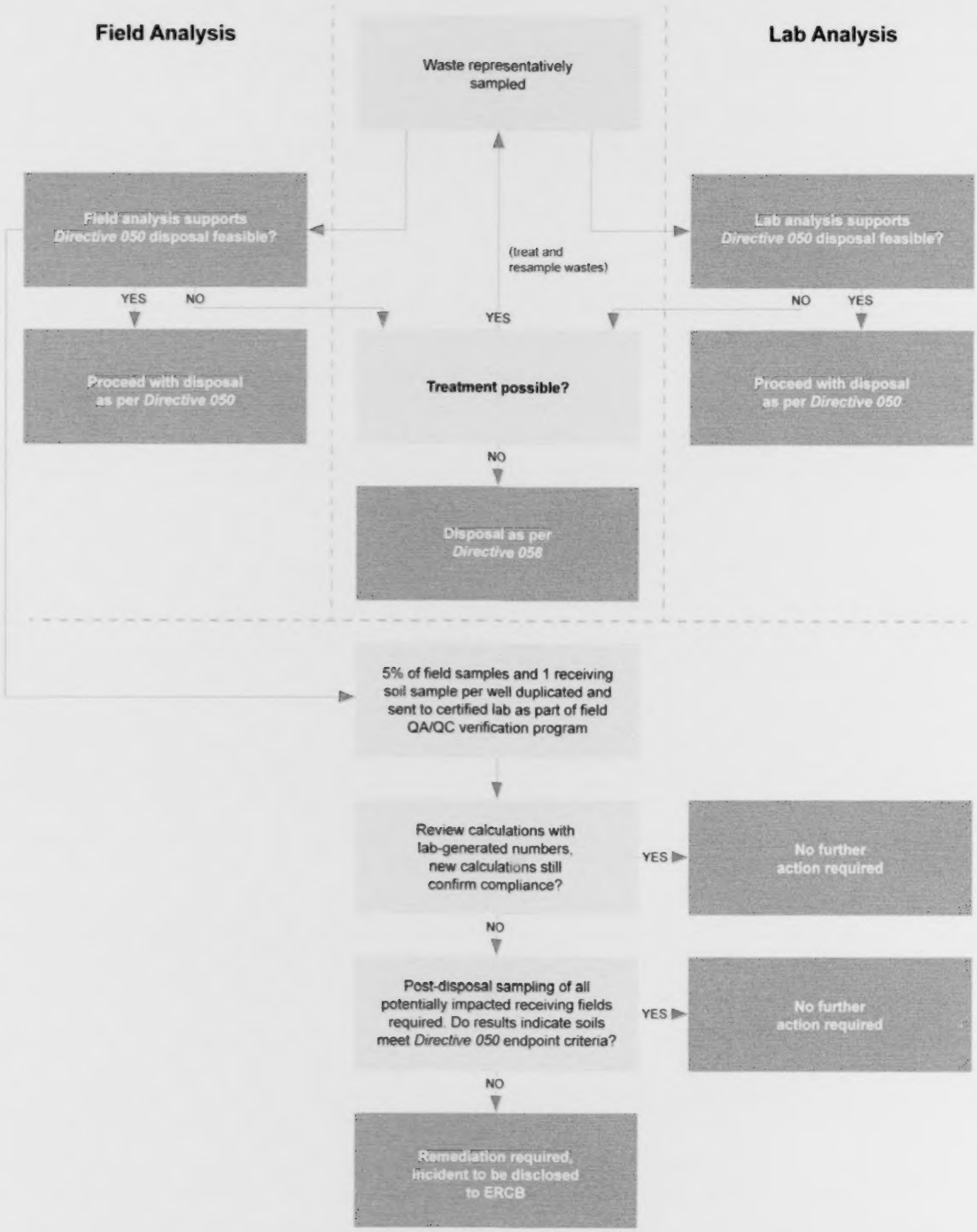

Field Analysis
Lab Analysis
Waste representatively sampled
Field analysis supports Directive 050 disposal feasible?
Lab analysis supports Directive 050 disposal feasible?
(treat and resample wastes)
YES
NO
NO
YES
YES
Proceed with disposal as per Directive 050
Treatment possible?
Proceed with disposal as per Directive 050
NO
Disposal as per Directive 058
5% of field samples and 1 receiving soil sample per well duplicated and sent to certified lab as part of field QA/QC verification program
Review calculations with lab-generated numbers, new calculations still confirm compliance?
YES
No further action required
NO
Post-disposal sampling of all potentially impacted receiving fields required. Do results indicate soils meet Directive 050 endpoint criteria?
YES
No further action required
NO
Remediation required, incident to be disclosed to ERCB

Figure 5.1 Field QA/QC verification program

6 Storage of Drilling Waste

6.1 Introduction

Drilling waste can be stored on the well site where it was generated or on a remote site. The systems typically used to store drilling waste are

- sumps, which are earthen excavations;
- alternative storage systems, which are aboveground tanks or other storage vessels, sumps lined with a synthetic liner, or other storage systems approved by the ERCB; and
- earthen-bermed storage systems, which are earthen structures built on grade.

6.2 General Drilling Waste Storage Requirements

1) Licensees must only put drilling waste in a drilling waste storage system. It is prohibited to mix camp sewage or other oilfield wastes (e.g., produced fluids, completion fluids, workover fluids, or spill material) with the drilling waste. It may be appropriate to direct rig washwater to a drilling waste storage system, provided only water-based drilling wastes are stored in it and only freshwater is used to wash the rig; this activity needs to be considered when assessing the drilling waste as it could be a source of toxicity.

2) Licensees must only use a storage system to store drilling wastes.

   NOTE: Licensees may (notwithstanding requirement 2) treat the drilling waste in a storage system to adjust pH, facilitate solids and liquids separation, or to reduce drilling waste toxicity.

3) If wishing to conduct other drilling waste treatment activites in a storage system, licensees must obtain written ERCB approval as set out in Section 19 prior to implementation of the treatment activity.

4) Licensees must locate the storage system or implement measures (e.g., site contouring, berms) to prevent the entrance of surface run-on/run-off waters. Precipitation landing within the storage system must be managed as drilling waste.

5) Licensees must ensure the exterior walls of drilling waste storage system are at least

   a) 20 m from an on-site rig water well,

   b) 50 m from any off-site water well, and

   c) 100 m from a water body.

   NOTE: Licensees may (notwithstanding requirement 5[c]) locate the drilling waste storage systems within a minimum distance of 50 m of a water body if either the

   - water body is up-gradient of the drilling waste storage system, or
   - landscape creates a physical barrier that would prevent the migration of drilling waste towards the water body.

6) Licensees must maintain a minimum freeboard of 0.5 m on all drilling waste storage systems. Seasonal precipitation rates, in addition to the volume of the expected drilling waste, must be considered when determining storage system capacities.

7) Licensees must secure the drilling waste storage system so that it is not a public hazard (e.g., implement measures to prevent public or wildlife from entering it).

8) Licensees must within 18 months of rig release of the first well that contributed drilling waste to the storage system

   a) remove the drilling waste from the storage system and manage it following the requirements of this directive; and

   b) physically close the storage system. Physical closure includes dismantling the storage system, decontaminating (if needed) the area beneath and surrounding it and, if applicable, backfilling/contouring the area used for the storage system.The objective is to close the storage system in a manner that will allow the site to be restored to equivalent land capability.

6.3 Sump Construction Requirements

9) Licensee must only construct a sump(s) on a site with appropriate deposits of clayey soils (i.e., meets the criteria set out in requirement 10(b) below) that are free of hydraulic defects such as gravel lenses, silt lenses, sand lenses, cracks, fissures, and root channels.

10) Licensees must have a qualified person conduct a site investigation to delineate the in situ clayey deposits. The site investigation must consist of

   a) a minimum of three boreholes, arranged in an approximate equilateral triangle, to establish the orientation of any significant geological plane. Sufficient lithology data (borehole) must also be gathered to confirm that the deposit of appropriate clayey material extends a minimum of 1 m beyond the horizontal and vertical dimensions of the sump.

   b) a representative clayey soil sample from each of the three boreholes analyzed in a lab to confirm that the clay deposit has the following characteristics:

      i) greater than 50 per cent fines (defined as dry weight percentage passing the No. 200 sieve)

      ii) greater than 20 per cent clay (i.e., 0.002 millimetre [mm] or smaller as determined by the hydrometer method)

      iii) a Liquid Limit (LL) equal to or greater than 30 per cent

      iv) a Plasticity Index (PI) equal to or greater than 10 per cent

   c) for sumps of an area of 100 m^2 or less (roughly 10 m x 10 m or less), the lab analysis required in (b) above can be reduced to one sample provided the three cores from the boreholes required in (a) above are similar in texture (i.e., hand texture method) and appearance, indicating limited variability for the characteristics set out in (b) above.

      NOTE: Reduction of lab analysis described in point (c) above does not apply to sites with more than one sump.

11) Before constructing the sump, licensees must prepare the site following typical well site and soil conservation practices. During sump construction it is important to determine whether naturally saline subsoils are being excavated. In situations where this occurs, care must be taken to appropriately stockpile these soils and replace them at an appropriate depth so that at the time of final reclamation the site can be restored to equivalent land capability.

6.4 Remote Drilling Waste Storage Requirements

A remote drilling waste storage sites is a drilling waste storage system that is either

- located on a stand-alone site or
- located on a well site that is receiving drilling waste from more than one well.

Note that licensees intending to recycle/re-use drilling waste to drill a subsequent well can temporarily store the drilling waste on the subsequent well site without designating it a remote storage site provided the subsequent well site holds an ERCB well licence, the drilling waste is stored in aboveground tanks, and the storage duration does not exceed three months in accordance with Section 3.5 of *Directive 055: Storage Requirements for the Upstream Petroleum Industry*.

The following requirements are additional to the requirements specific to the type of drilling waste storage system being used.

12) Licensees must ensure that only wells for which they are the licensee contribute drilling waste to a drilling waste storage system(s) on a remote site.

13) If the remote drilling waste storage system is located on a site other than a licensed well site, licensees must obtain a written agreement from the landowner or department agency managing the land on behalf of the provincial or federal Crown (e.g., a surface lease or right-of-entry agreement or a disposition under the *Public Lands Act*).

14) If the remote drilling waste storage system is located on a site other than a licensed well site, licensees must have signage at the site entrance identifying the legal subdivision (LSD), the licensee, the well licence to which the site is linked (see requirement 15 below), and a 24-hour emergency phone number. The site must be secured so that it is not a public hazard (e.g., fence the sump or implement other measures to prevent the public or animals from entering it).

15) For liability tracking purposes, licensees must tie back (i.e., link) the remote drilling waste storage site to the well licence that generated the drilling waste. In situations where more than one well contributes drilling waste to the remote drilling waste storage system, licensees must tie back (i.e., link) the remote drilling waste storage site to the licence of the well that first contributed drilling waste.

Refer to Section 8.2(5)(c) for remote site tracking requirements for pipeline-generated drilling wastes.

6.5 Earthen-bermed Storage System Requirements

16) Licensees must only use earthen-bermed storage systems

a) to store nonhydrocarbon-based drilling waste solids (i.e., cuttings) intended to be landspread or managed at an approved waste management facility; and

b) on a well site or remote drilling waste storage site that has been prepared following typical well site and soil conservation practices (i.e., topsoil removed and conserved).

17) Licensees must assess the shallow subsoils of the area on which the earthen-bermed storage system is to be constructed and verify the subsoils are of limited permeability. The assessment must consist of the following:

a) As a minimum, three subsoil samples must be taken from the area on which the bermed storage system will be constructed. Each sample must be analyzed to confirm that for a minimum depth of 30 cm, the soil forming the base of the system has the following characteristics:

i) greater than 50 per cent fines (defined as dry weight percentage passing the No. 200 sieve), and

ii) greater than 20 per cent clay (i.e., 0.002 mm or smaller as determined by the hydrometer method).

18) Licensees must construct the berms with clayey soil meeting the characteristics set out in requirement 17 above. The berms must be of sufficient capacity, but at least 15 cm high, to contain any generated leachate and to prevent the flow of surface water into the storage system.

19) Licensees must locate the earthen-bermed storage system such that the exterior walls of the berms are set back at least 20 m from any on-site rig water supply well and 50 m from any off-site water well.

6.6 Reuse of a Drilling Waste Storage System Requirements

20) Licensees must not re-use an earthen-bermed storage system.

21) Licensees wishing to reuse a drilling waste storage system (other than an earthen-bermed storage system) for another drilling program must verify its integrity prior to reuse.

22) Licensees must submit a notification to the ERCB at least 30 days prior to the intended day of reuse. The notification must

a) identify the location of the site on which the drilling waste storage system is located and, if on a well site, the licence number for the well,

b) describe the method used to verify the integrity of the drilling waste storage system and determine its appropriateness for reuse,

c) describe any additional construction work done to prepare the drilling waste storage system for reuse,

d) provide verification that the landowner/department/agency has agreed to the reuse of the drilling waste storage system,

e) commit to meet the requirements set out in Sections 6.2, 6.3, and 6.4,

f) identify the number of previous drilling programs for which the drilling waste storage system has been used and the age of the system, including the well license number of the first well that contributed drilling to the storage system, and

g) verify that the site, overall, has not been used to store drilling wastes for a period that exceeds five years.

23) Licensees must electronically submit the notification to the ERCB in .pdf as an e-mail attachment as follows:

a) E-mail the notification to Directive050@ercb.ca.

b) Ensure that the attachment file name identifies it as a drilling sump-storage reuse notification, contains the applicable well licence number and the UWI to which the site is linked as described in Section 6.4(15), and is formatted as DW_License#_UWI (e.g., SumpReuseDW_0123456_00~12-14-025-12W4~0).

c) Ensure that the subject field of the e-mail contains the file name.

The ERCB will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliant event in accordance with *Directive 019*.

NOTE: Sites used to store/manage drilling waste for a duration longer than five years require approval as oilfield waste management facilities and are subject to the requirements and application process set out in *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*, which includes meeting *Directive 055: Storage Requirements for the Upstream Petroleum Industry*.

6.7 Storage of Hydrocarbon-based Drilling Wastes Requirements

24) Licensees must store liquid hydrocarbon-based drilling wastes in tanks, and, the solids from hydrocarbon-based drilling wastes must be stored in a manner that prevents contact with the ground. Suitable storage options include

a) lining the sump or earthen-bermed storage system with a synthetic liner or

b) containing the drilling waste solids in tanks or other storage vessels.

7 Management of Cement Returns

7.1 Introduction

In some situations, cement returns are not isolated from the drilling waste and get placed in the sump and are managed with the solids using the mix-bury-cover method. This practice is acceptable provided all of the requirements for mix-bury-cover are met.

7.2 Requirements

1) Licensees must use one of the following options to manage cement returns that have been isolated from the drilling waste

   a) allow the isolated cement returns to harden in aboveground synthetically lined walled storage systems (AWSS), which are often called cement rings. The following requirements must be met when using AWSSs for storage of cement returns:

      i) the capacity must not exceed 50 m^3;

      ii) the synthetic liner must be at least 12 mil thick, have properties (i.e., density, tensile strenght, elongation, tear resistance, and puncture resistance) suitable for the intended use, be chemically resistant to the compounds used to formulate the cement, and be rated for the temperatures encountered (i.e., the temperature of the cement returns and the ambient temperatures). The manufacturers' liner specifications must be documented;

      iii) the wall system must be engineered to withstand the hydraulic pressure of the stored contents at full capacity;

      iv) the liner must cover the ground floor of the walled system, extend up the wall and be fastened onto the outside of the wall;

      v) the system used to fasten the liner must secure the liner to the wall system but must not damage the liner;

      vi) the storage duration must not exceed one year; within the one-year timeframe, the cement returns must be removed and the AWSS must be dismantled;

      vii) the removed, hardened cement returns must be broken into pieces 0.5 m^3 or less in size and placed into pits meeting requirement (c) below, or be managed in accordance with requirements (d) or (e) below; and

      viii) liners must not be reused and must be managed as an oilfield waste in accordance with *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*.

   b) allow the isolated cement returns to harden in aboveground portable rigid structures that will adequately contain the cement returns and prevent releases into the environment. The following requirements must be met when using portable structures for storage of cement returns:

      i) the structures must be able to withstand the hydrostatic pressure of the stored contents at full capacity;

ii) the storage duration must not exceed one year; within the one-year timeframe, the cement returns must be removed from the portable structure; and

iii) the removed, hardened cement returns must be broken into pieces 0.5 m^3 or less in size and placed into pits meeting requirement (c) below, or be managed in accordance with requirements (d) or (e) below.

c) place the isolated cement returns into a segregated pit (or pits) on the originating well site or associated remote drilling waste storage site, allow the cement to harden, break the cement into pieces 0.5 m^3 or less in size, and cover the pieces with at least 1 m of clean fill. In addition,

i) written landowner consent must be obtained before placing cement returns into the pit(s) in situations where one pit or the collective area of more than one pit exceed 4 m^2;

ii) the pit(s) must not be constructed in the water table;

iii) the area of one pit, or collective area of more than one pit, on one well site, multi-well site, or remote drilling waste storage site, must not exceed 100 m^2 (i.e., about 10 m by 10 m);

iv) notwithstanding requirement (iii) above, if the well(s) that generated the cement returns is part of an oilsands development and the well site, multi-well site, or remote drilling waste storage site on which the cement return pit(s) is located is on Public Lands, the area of one pit or collective area of more than one pit, must not exceed 900 m^2 (i.e., about 30 m by 30 m);

v) measures must be implemented to prevent the public or animals from entering the pit(s);

vi) the buried cement returns must not interfere with subsurface water flow and the objective to restore the site to equivalent land capability; and

vii) the buried cement returns must be disclosed during the reclamation process for the well site or remote drilling waste storage site.

d) place the isolated cement returns into cells that are part of an approved landfill; landfills established on ERCB-regulated upstream petroleum sites are subject to the application and approval process set out in *Directive 058;* all other landfills in Alberta are subject to the application and approval process prescribed by the *EPEA*

e) apply to the ERCB for approval to manage or recycle the cement returns in an alternative manner (see Section 19).

8 Drilling Wastes from Pipelines

8.1 Introduction

Directional drilling for the purpose of pipeline construction is often practised by the oil and gas industry as a method for mitigating environmental impacts. As such, the toxicity of the drilling mud, the impact of drilling mud releases on water quality or infrastructure, and methods of drilling-waste storage and disposal must be considered before beginning the directional drilling.

Note that *CSA Z662-11, Oil and Gas Pipeline Systems*, contains a number of requirements pertaining to horizontal drilling of pipeline crossings, including the need for a drilling execution plan (which includes drilling fluid management), personnel training, and pipe handling. These requirements are mandatory for installation of pipeline in Alberta in accordance with the *Alberta Pipeline Regulation*.

The requirements set out in this section pertain to the storage and disposal of drilling waste from directional drilling activities for pipeline construction.

8.2 Requirements

1) Licensees must evaluate the toxicity of additives, products, and chemicals added to the drilling mud system to verify that all are used in concentrations below the accepted pass threshold for the luminescent bacteria toxicity test ($EC50|15| \geq 75$ per cent). Refer to Section 4.3 for more information on drilling waste assessment.

   NOTE: Drilling systems composed solely of freshwater and bentonite are considered nontoxic by the ERCB and do not require toxicity evaluations.

2) If the toxicity is not known for any of the additives, products, or chemicals, licensees must

   a) develop a generic mud system that mimics the mud formulation that will be used for the drilling program (it must contain the highest concentration of individual mud products/fluid additives that would be used in the mud system) and test it for metals (refer to Table 3.4), toxicity (luminescent bacteria), and salinity (EC, SAR, Na, N) [refer to Section 4.4]; and

   b) only use the mud system for drilling if the generic mud system passes the luminescent bacteria toxicity test. Use the metal and salinity information to make decisions about potential drilling waste disposal methods and meet requirements for the disposal methods that are actually used.

3) Licensees must appropriately store drilling muds and wastes at the entry and exit points of the drilling activity. Acceptable storage systems include

   a) earthen pits that are constructed in clayey soils that contain at least 20 per cent clay and 50 per cent fines and extend at least 1 m beyond the bottom and sides of the pit;

   b) tanks, conductor barrels, or lined earthen pits; or

   c) earthen pits not meeting the criteria specified in (a) above, provided the drilling mud/waste released into the pit is immediately and continually removed during the drilling activity and stored/managed in accordance with this directive.

4) Immediately upon completion of drilling, licensees must remove the drilling waste from the pits and manage it in accordance with the methods set out in this directive, then backfill/reclaim the pits.

   NOTE: Mix-bury-cover and landspreading disposal methods are limited to an area of a pipeline right-of-way that has a disturbed surface (e.g., top soil has been removed, right-of-way is under construction or has been disturbed for pipeline work), or to a remote site that meets requirement 5 below. Disposal of drilling waste on a pipeline right-of-way is limited to those generated from construction of the pipeline associated with the right-of-way. Landowner/department/agency consent is required prior to conducting landspray, LWD, or pump-off disposals when the surface of the pipeline right-of-way is restored and is being used by the landowner/department/agency.

5) Licensees using a remote site must

   a) have a written agreement from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (e.g., a surface lease or right of entry agreement, or disposition under the *Public Lands Act*) as set out in Section 1.6 of this directive;

   b) meet the storage requirements set out in Sections 6.2, 6.3, and 6.4 of this directive;

   c) tie back (i.e., link) the remote site to the licence and line number of the pipeline that generated the drilling waste, and meet applicable reclamation obligations for the site as described in Section 1.7 of this directive; and

   d) within one year of the first receipt of drilling waste into the storage system

      i) remove the drilling waste and manage it in accordance with the methods set out in this directive, and

      ii) physically close the storage system. Physical closure includes dismantling the storage system, decontaminating (if needed) the area beneath and surrounding it and, if applicable, backfilling/contouring the area used for the storage system. The objective is to close a storage system in a manner that will allow the site to be restored to equivalent land capability.

6) For drilling waste that has been generated from directional drilling activities, licensees must document the following information and retain it until the pipeline has been abandoned. If a remote site was used to manage the drilling waste, licensees must document the following information and retain it until the remote site has been successfully reclaimed (e.g., a reclamation certificate for sites designated as specified lands, or alternative documentation from the department/agency responsible for nonspecified lands).

   a) the pipeline segment (licence and line number) that generated the drilling waste;

   b) the pipeline "from" and "to" location (i.e., the LSD);

   c) the legal land location (i.e., the LSD) and the plot plan showing the entry and exit pits of the directional drill, and a description of the method used to prevent migration of drilling mud/waste during drilling (e.g., tanks, liners, conductor barrels) in the event that the pit does not consist of suitable clayey soils;

d) if a remote site was used, its LSD and specific use (e.g., storage including type of storage system, and disposal including type of disposal method), and a plot plan showing the storage and disposal areas;

e) the type of mud system used and a list of all of the additives, products, or chemicals used, including the volume used, and documentation to verify the mud system was nontoxic (refer to requirements 1 and 2 above);

f) the volume of drilling waste generated and the management method used, including documentation to demonstrate compliance with the requirements for the selected method;

g) proof of landowner/department/agency consent or agreement, including a "plan of survey" of the disposal site(s);

h) a copy of the completed form from requirement 7 below.

7) Licensees must electronically submit post-disposal information identifying the drilling waste volumes generated, storage systems used, disposal methods used, and locations of disposals. Within 12 months of each directional drilling activity, licensees must fill out and submit a *Directive 050: Drilling Waste Pipeline Disposal Form* through the Digital Data Submission (DDS) screen on the ERCB website at www.ercb.ca. The Drilling Waste Pipeline Disposal Form is located under ERCB/Submissions/Drilling Waste Data; select Pipeline Disposal as the Submission Type.

Note that authorized ERCB customers require a login ID and password to access the DDS system. For help getting a login ID, contact your company's ERCB DDS administrator. If you are unable to contact your company's ERCB DDS administrator, contact DDSAdminstrator@ercb.ca.

9 Landspray

9.1 Introduction

The landspray disposal method involves spraying fluid or total waste onto topsoil and may or may not involve incorporating the waste into the soil. Incorporation is typically done when the drilling waste has been landsprayed on cultivated land. It is accomplished by mechanically combining the drilling waste into a homogeneous soil/waste mix. Drilling waste that has been landsprayed on vegetated land is typically not incorporated. A calculated loading rate or maximum application rate is used to determine the area required for landspraying.

Vegetated lands include grasslands, native prairie, and forage lands, but not forested Public Lands. Refer to Section 11 for requirements that are specific to disposal on forested Public Lands.

While landspray is typically conducted outside of the lease boundaries of a well site or remote drilling waste storage site, this does not preclude conducting landspray operations on the well site that generated the drilling waste or on a remote site, provided the drilling waste was stored on the remote site. Landspray may also be used on well site access roads provided these locations are leased or owned by the well licensee and landowner/department/agency written consent has been obtained. Landspray disposal on pipeline-right-of-ways is limited to drilling waste resulting from directional drilling for construction of the pipeline associated with the pipeline right-of-way.

Note that it is not permissible for a licensee to use the landspray disposal method for hydrocarbon-based drilling wastes.

Refer to Table 9.1 for a summary of the requirements for the landspray disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

9.2 Landspray Receiving Soil Requirements

1) Licensees must only select land for the landspray disposal method that:

   a) has a slope of less than 5 per cent for summer (unfrozen ground) operations or a slope of less than 3 per cent for winter (frozen and snow covered) operations,

   b) is not within 10 m of a road ditch or property line,

   c) is not within 100 m of a water body, and

   d) is not within 50 m of a water well.

   NOTE: Licensees may (notwithstanding requirement 1(c) above) reduce the water body separation distance to 50 m if the water body is upgradient of the selected dipsoal area or if the landscape creates a physical barrier that would prevent the drilling waste from migrating towards the water body.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) Select one sampling site for every 4 ha of a disposal area.

b) Ensure each sampling site is a circular area with a 10 m radius and a centre precisely located and documented (by Global Positioning System [GPS] universal transverse mercator [UTM], such as North American Datum 1983 [NAD83]) along with bearing and metres from a fixed point.

c) As a minimum, collect one composite sample for the 0 to 10 cm soil depth increment from each sampling site. For landspray without soil incorporation, take the sample from the soil profile beneath the leaf litter layer, if present. Each composite sample must comprise five subsamples.

3) Licensees must assess the receiving soil as set out in Section 3 to confirm its suitability for the landspray disposal method.

4) Licensees must (except when the disposal is occurring on a well site, remote drilling waste storage site, or an area of a pipeline right-of-way that has a disturbed surface) obtain written consent from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to Section 1.6) before beginning any landspray activities.

9.3 Landspray Disposal Requirements

5) Licensees must segregate cement returns from the drilling waste and manage them as set out in Section 7.

6) Licensees must manage separated solids and cuttings by a different method (e.g., mix-bury-cover, landspreading, biodegradation) or, alternatively, send them to an approved waste management facility. If the drilling waste was originally tested as a total waste and the volume of the separated solids and cuttings is less than 20 m^3, separate analysis is not required unless further information is needed to meet the requirements of the other disposal method.

7) Licensees must contain the drilling waste in a storage system prior to landspraying, and

a) take a fluids sample to determine the suitability of the method, if only the fluids are to be landsprayed and the solids are to be managed by another option, or

b) take a total waste sample to determine the suitability of the method, if the fluid and solid phases are to be landsprayed together.

8) Licensees must analyze the drilling waste sample for the parameters listed below, and use the results to determine spread rates that will prevent the receiving soil from exceeding the soil endpoints for salts, hydrocarbons, and metals set out in Section 3:

a) pH, EC, SAR, sodium (Na), and toxicity;

b) nitrogen (N), if the cumulative amount of N (NH_4-N, NO_3-N, NO_2-N) in additives/products added to the drilling mud or waste system exceeds 100 kg or is unknown;

c) metals, if cumulative concentrations of metals in mud additives/products added to the drilling mud system exceed the concentrations set out in Table 3.4 or are unknown; and

d) hydrocarbons, if a hydrocarbon flag is present.

9) Licensees must ensure that

   a) the pH of the drilling waste is not less than 6 or greater than 10.5;

   b) the drilling waste passes a toxicity test. For those drilling wastes that only pass the toxicity test after being charcoal-treated, disposal may only proceed if hydrocarbons are the likely source of toxicity (refer to Section 4.3);

   c) the minimum drilling waste spread rate is not less than 10 m^3/ha (note that the calculated spread rate for a parameter decreases as the concentration of the parameter in the drilling waste increases);

   d) the maximum drilling waste spread rate does not exceed 40 m^3/ha for summer (unfrozen ground) operations;

   e) the maximum drilling waste spread rate does not exceed 20 m^3/ha for winter operations, which are in effect when the soil is saturated with water, ice covered, snow covered, or frozen. Spread rates for winter operations must be determined using calculations for application "without soil incorporation."

   f) in winter operations when the disposal area is snow covered, the disposal area is prepared so that the drilling waste is applied to the surface of the disposal area and not onto snow accumulation;

   g) the drilling waste does not clump or pool on the land, migrate off the disposal area, or cause land erosion;

      NOTE: To avoid physical issues such as pooling, erosion, or waste migration, the maximum summer and winter application rates are the "actual maximum spray rates" that can be applied to the disposal area.

   h) the sodium application rate does not exceed 250 kg/ha and the nitrogen application rate does not exceed 25 kg/ha; and

   i) the solids application rate does not exceed 6 tonne (t)/ha when spraying onto vegetated lands, and the landspray does not smother or stress the vegetation (i.e., clumping or uneven application resulting in vegetation being coated with drilling waste).

10) Licensees wishing to exceed the nitrogen application rate of 25 kg/ha must submit an application and obtain ERCB approval for an alternative management method as set out in Section 19 of this directive; information based on Section A2.3 of Appendix 2 must be provided to support the application.

11) If the waste is treated (e.g., pH adjusted, hydrocarbons removed), licensees must have the waste resampled and reanalyzed to determine its suitability for a landspray disposal method.

12) If spread rates were determined by the calculations for "soil incorporation," licensees must ensure that the drilling waste is incorporated into the receiving soil to a maximum depth of 15 cm within 60 days of disposal. If incorporation is not done right after application, licensees must select sites where it is reasonable that migration of drilling waste from the application area would not occur within the 60 days allowed for

incorporation; otherwise, licensees must use spread rates calculated for application without soil incorporation.

13) If landspraying is to be done without soil incorporation, licensees must determine spread rates using the calculations for "no soil incorporation."

14) Licensees must discuss compaction and access impact (rutting) with the landowner/department/agency prior to disposal to ensure that both parties have understood each other's expectations.

9.4 Landspray Post-disposal Requirements

15) Licensees must conduct post-disposal sampling within 60 days of the disposal (but preferably directly after completing the disposal) and analyze the waste/soil mix to verify that the applicable soil endpoints set out in Section 3 have not been exceeded if

a) the EC of the drilling waste exceeds 10 dS/m, the nitrogen loading rate exceeds 20 kg/ha, or the sodium loading rate exceeds 150 kg/ha—analyze for EC, SAR, Na, and N (NH_4-N, NO_3-N, NO_2-N);

b) the concentration of metals in the drilling waste exceeds any of those set out in Table 3.5—analyze for metals; or

c) a hydrocarbon flag was encountered and the hydrocarbon concentration in the drilling waste exceeds the values for any of the parameters set out in Table 3.3—analyze for hydrocarbons.

Table 9.1 Summary of landspray disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving soil • topsoil with EC < 2 dS/m, SAR < 4 Site • slope must be less than 5% in summer operations and less than 3% in winter operations • 50 m setback from a water well • 100 m setback from a water body • 10 m setback from a road ditch or property line • landowner or Crown department/ agency consent for disposal Waste • limited to water-based drilling wastes • segregate cement returns and drillstem fluids from drilling waste • separated solids or drill cuttings to be managed by another method	Fluids or total waste • must pass a toxicity assessment • pH between 6 and 10.5 • maximum spread rate of 20 m^3/ha in winter conditions and 40 m^3/ha in summer conditions • maximum solids application rate for vegetated lands: 6 t/ha • minimum spread rate: 10 m^3/ha • if cumulative concentration of metals in mud additives/products exceed values in Table 3.4 or are unknown, analyze drilling waste; use results to calculate spread rates • if hydrocarbon flag encountered, analyze drilling waste and use BTEX and F1 to F4 hydrocarbon results to calculate spread rates to prevent exceedances of criteria in Table 3.2	Soil/waste mix limited to a maximum increase of one unit beyond background soil EC and SAR, but not to exceed an EC of 2 dS/m or SAR of 4 Maximum Na loading rate: 250 kg/ha Maximum N loading rate: 25 kg/ha Soil/waste mix must not exceed soil hydrocarbon and metal endpoints in Tables 3.2 and 3.4	Receiving soil • EC and SAR Fluids or total waste • pH, EC, SAR, and Na • N, if an unknown amount or an amount ≥100 kg N was added to drilling mud or waste system • metals, if metals added to mud system in excess of concentrations in Table 3.4 or are unknown • hydrocarbons, if hydrocarbon flag encountered • toxicity assessment Waste/soil mix (post-disposal) • EC, SAR, Na, and N, if the drilling waste exceeds an EC of 10 dS/m, the N loading rate exceeds 20 kg/ha, or if the Na loading rate exceeds 150 kg/ha • metals, if concentrations in the drilling waste exceed concentrations listed in Table 3.5 • hydrocarbons, if concentrations in the drilling waste exceed concentrations listed in Table 3.3

[1] This table summarizes the landspray requirements, but the details within the numbered requirements of Section 9 will be used for assessing compliance with the landspray disposal method.

10 Landspray-While-Drilling

10.1 Introduction

The landspray-while-drilling (LWD) disposal method involves spraying drilling wastes onto topsoil at controlled, low-application rates. LWD is limited to drilling wastes from water-based drilling mud systems, which are shown to be nontoxic using the luminescent bacteria toxicity test.

The landspray and LWD disposal requirements are similar, but as the LWD method is limited to only nontoxic mud systems, the testing requirements have been reduced, and disposal is allowed to proceed without first storing the drilling waste (e.g., by sumpless drilling). The controlled application is normally conducted during the drilling operation. Spraying techniques may include the use of vacuum trucks or similar equipment.

Although incorporation of the drilling waste into the receiving soil is at the discretion of the landowner, the intent of this disposal method is to meet all applicable endpoints without the need for incorporation. Should incorporation be necessary to meet endpoints, then the landspray disposal method must be used, with all applicable criteria.

While LWD is typically conducted outside of the lease boundaries of a well site or remote drilling waste storage site, this does not preclude conducting the LWD operations on the well site that generated the drilling waste. Small volumes of fluids may be landsprayed on access roads to the well site provided these locations are leased or owned by the licensee and landowner/department/agency written consent has been obtained. LWD disposal on pipeline-right-of-ways is limited to drilling wastes resulting from directional drilling for construction of the pipeline associated with the pipeline right-of-way.

Refer to Table 10.1 for a summary of the requirements for the LWD disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

10.2 Landspray-While-Drilling Receiving Soil Requirements

1) Licensees must only select land for the LWD disposal method that

   a) has a slope of less than 5 per cent for summer (unfrozen ground) operations or a slope of less than 3 per cent for winter (frozen and snow covered) operations,

   b) is not within 10 m of a road ditch or property line,

   c) is not within 100 m of a water body, and

   d) is not within 50 m of a water well.

   NOTE: Licensees may (notwithstanding requirement 1(c) above) reduce the water body separation distance to 50 m if the water body is upgradient of the selected dipsoal area or if the landscapre creates a physical barrier that would prevent the drilling waste from migrating towards the water body.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) Select one sampling site for every 4 ha of a disposal area.

b) Ensure each sampling site is a circular area with a 10 m radius and a centre precisely located and documented (by Global Positioning System [GPS] universal transverse mercator [UTM], such as North American Datum 1983 (NAD83]) along with bearing and metres from a fixed point.

c) As a minimum collect one composite sample for the 0 to 10 centimetre (cm) soil depth increment from each sampling site. Take the sample from the soil profile beneath the leaf litter layer, if present. Each composite sample must comprise five subsamples.

3) Licensees must assess the receiving soil as set out in Section 3 to confirm its suitability for the landspray-while-drilling disposal method.

4) Licensees must (except when the disposal is occurring on a well site, remote storage site, or an area of a pipeline right-of-way that has a disturbed surface) obtain written consent from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to Section 1.6) before beginning any landspray activities.

10.3 Landspray-While-Drilling Disposal Requirements

5) Licensees must segregate cement returns from the drilling waste and manage them as set out in Section 7.

6) Licensees must isolate drillstem test fluids and any sections of the mud system that are contaminated by hydrocarbons and manage them by a different method.

7) Licensees must either manage separated solids and cuttings by a different method (e.g., mix-bury-cover, landspreading, biodegradation) or send them to an approved waste management facility. If the drilling waste was originally tested as a total waste and the volume of the separated solids and cuttings is less than 20 m^3, separate analysis is not required unless further information is needed to meet the requirements of the other disposal method.

8) Licensees must sample and analyze the drilling waste for pH, EC, SAR, Na, and N (if the cumulative amount of N [NH_4-N, NO_3-N, NO_2-N] in additives/products added to the drilling mud or waste system exceeds 100 kg or is unknown).

9) Licensees must only use the LWD disposal method for water-based drilling mud systems where the resulting drilling waste (fluids or total waste)

a) has a pH within the range of 6 to 10.5;

b) has an EC that does not exceed 16 dS/m;

c) contains no visible hydrocarbons, and no other hydrocarbon flags were encountered while the well was drilled;

d) does not contain cumulative concentrations of metals from mud additives/products that exceed the values set out in Table 3.4 (another disposal option must be used if metal content is unknown); and

e) does not contain any mud additives/products that were used in concentrations above the luminescent bacteria toxicity test pass threshold (EC50[15] $\geq$ 75 per cent)

(another disposal option must be used if the toxicity of any of the mud additives/products is unknown).

NOTE: Licensees can compensate for points (d) and (e) above by following the "generic mud system" protocol as set out in Section 4.3(10).

10) Licensees must ensure that

a) the minimum drilling waste spread rate is not less than 10 m^3/ha (note that the calculated spread rate for a parameter decreases as the concentration of the parameter in the drilling waste increases);

b) the maximum drilling waste spread rate does not exceed 40 m^3/ha for summer (unfrozen ground) operations;

c) the maximum drilling waste spread rate does not exceed 20 m^3/ha for winter operations, which are in effect when the soil is saturated with water, ice covered, snow covered, or frozen;

d) spread rates are determined using calculations for application "without soil incorporation;"

e) in winter operations when the disposal area is snow covered, the disposal area is prepared so that the drilling waste is applied to the surface of the disposal area and not onto snow accumulation;

f) the drilling waste does not clump or pool on the land, migrate off the disposal area, or cause land erosion;

NOTE: To avoid physical issues such as pooling, erosion, or waste migration, the maximum summer and winter application rates are the "actual maximum spray rates" that can be applied to the disposal area.

g) the sodium application rate does not exceed 250 kg/ha, and the nitrogen application rate does not exceed 25 kg/ha; and

h) the solids application rate does not exceed 6 t/ha when spraying onto vegetated lands, and the landspray does not smother or stress the vegetation (i.e., clumping or uneven application resulting in vegetation being coated with drilling waste).

11) If wishing to exceed the nitrogen application rate of 25 kg/ha, licensees must use another diposal method (e.g., landspray) and obtain ERCB approval for an alternative management method as set out in Section 19 of this directive; information based on Section A2.3 of Appendix 2 must be provided to support the application.

12) Licensees must separate and handle drilling wastes as different sections of the well are drilled (e.g., top, middle, and bottomhole) if changes are made to the drilling mud formulation for the different well sections and it cannot be confirmed that the conditions of requirement 9 and 10 above will continue to be met.

13) Licensees must ensure that LWD disposal operations occur within 48 hours of rig release. Under extreme weather conditions, drilling waste can be stored in tanks for a maximum of 96 hours after the rig has been released, but the drilling waste must be retested before

beginning the LWD operations. An alternative management option must be used if this timeline cannot be achieved.

10.4 Landspray-While-Drilling Post-disposal Requirements

14) Licensees must conduct post-disposal sampling of the waste/soil mix within 60 days of the disposal (but preferably directly after completing the disposal activity) and compare the results to the applicable soil endpoints set out in Section 3 if

a) the EC of the drilling waste exceeds 10 dS/m—analyze for EC and SAR,

b) the nitrogen loading rate exceeds 20 kg/ha—analyze for N (NH_4-N, NO_3-N, NO_2-N), or

c) the sodium loading rate exceeds 150 kg/ha—analyze for EC, SAR, and Na.

Table 10.1. Summary of landspray-while-drilling disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving soil • topsoil with EC < 2 dS/m, SAR < 4 Site • slope must be less than 5% for summer operations and less than 3% for winter operations • 50 m setback from a water well • 100 m setback from a water body • 10 m setback from a road ditch or property line • landowner or Crown department/agency consent for disposal Waste • limited to nontoxic, water-based drilling wastes where no hydrocarbon flags were encountered • segregate cement returns, drillstem fluids, and sections of the mud system contaminated with hydrocarbons • separated solids or drill cuttings must be managed by mix-bury-cover or landspreading or sent to a waste facility for disposal	Fluids or total waste • pH between 6 and 10.5 • EC ≤ 16 dS/m • no visible hydrocarbons • cumulative concentration of metals in mud additives/products must not exceed values in Table 3.4 • mud additives/products used in concentrations below pass threshold level for luminescent bacteria toxicity test • maximum spread rate of 20 m^3/ha in winter conditions and 40 m^3/ha in summer conditions • maximum solids application rate for vegetated lands: 6 t/ha • minimum spread rate: 10 m^3/ha	Soil/waste mix limited to a maximum increase of one unit beyond background soil EC and SAR, but not to exceed an EC of 2 dS/m or an SAR of 4 Maximum Na loading rate: 250 kg/ha Maximum N loading rate: 25 kg/ha Soil/waste mix must not exceed soil hydrocarbon and metal endpoints in Tables 3.2 and 3.4	Receiving soil • EC and SAR Liquids or total waste • pH, EC, SAR, Na • N , if an unknown amount or an amount ≥100 kg N was added to the drilling mud or waste system Waste/soil mix (post-disposal) • EC, SAR, Na, and N, if the drilling waste exceeds an EC of 10 dS/m, the N loading rate exceeds 20 kg/ha, or if the Na loading rate exceeds 150 kg/ha

[1] This table summarizes the LWD requirements, but the details within the numbered requirements of Section 10 will be used for assessing compliance with the LWD disposal method.

11 Disposal onto Forested Public Lands

11.1 Introduction

The requirements set out in this section are limited to the application of drilling wastes from nontoxic, water-based mud systems onto forested Public Lands (also referred to as green areas).

Disposal onto forested Public Lands (DFPL) is used mainly in the winter where drilling waste fluids or total waste (slurried solids and fluid) are applied to specific types of dispositions issued pursuant to the *Public Lands Act*. The method is suited particularly to drilling wastes from shallow wells and winter-access-only wells and to minimum-ground-disturbance winter operations. This method reduces the need to construct sumps, which reduces the need to remove timber to accommodate oil and gas operations. Although similar to LWD with respect to the applicable type of drilling waste and the opportunity to conduct sumpless drilling, this method allows higher drilling waste application rates.

Application methods include applying the drilling waste at a predetermined rate with a vacuum truck, a terragator, or a wagon equipped with a spray bar or deflector; application with hoses or other similar equipment is not suitable.

This method may be used alone or in combination with other methods, such as mix-bury-cover or landspreading on the well site or a remote sump site under a mineral surface lease.

Refer to Table 11.1 for a summary of the requirements for the DFPL disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

11.2 Disposal onto Forested Public Lands Site and Receiving Soil Requirements

1) Licensees must only conduct DFPL on lands for which SRD has issued the following types of dispositions:

   a) mineral surface leases (MSLs), which include well sites, remote sump sites, and some short access roads; and

   b) licences of occupation (LOCs), which include developed and undeveloped roads.

2) Licensees must ensure that the licensee of the well that generated the drilling waste is also the holder of the disposition and obtain consent from SRD to dispose of drilling waste.

3) Licensees must not conduct the disposal in the ditches of a developed LOC (e.g., where a roadbed has been constructed). Any disposal on an MSL or LOC in a minimum-ground-disturbance (MGD) operation, as identified by SRD, must be restricted to cleared areas. In addition,

   a) under summer MGD (unfrozen) conditions, blade about 10 to 15 cm of the developed LOC surface to both sides to form earthen windrows, apply the waste in several passes (without exceeding the disposal limit) and mix in, then replace the windrowed soil; and

b) under winter MGD (frozen) conditions, lands under an LOC (whether developed or not) must be ploughed to create snow windrows, and the waste must be applied in several passes (without exceeding the disposal limit) between the snow windrows.

4) Licensees must not conduct DFPL on

a) other accesses, seismic lines, or existing clearings and openings on Public Lands;

b) areas with a slope greater than 5 per cent;

c) areas where the applied drilling waste could pool, cause erosion, or migrate into lakes or watercourses (e.g., transmitted through ditches, ditched roads, or natural drainage channels);

d) locations within 100 m of a water body, 50 m of a water well, and 10 m of ditches or property lines; and

e) receiving soils where the depth to the mineral soil horizon is greater than 30 cm and/or where vegetative indicators (e.g., tamarack, stunted black spruce) indicate unsuitable receiving soils, such as open muskeg.

NOTE: Licensees may (notwithstanding requirement 4[d]) reduce the water body separation to 50 m if the water body is upgradient of the selected disposal area or if the landscape creates a physical barrier that would prevent migration of the drilling waste towards the water body.

5) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

a) Select one sampling site for every 4 ha of a disposal area.

b) Ensure each sampling site is a circular area with a 10-m radius and a centre precisely located and documented by GPS [UTM], such as NAD83, along with bearing and metres from a fixed point.

c) As a minimum, collect one composite sample from the 0- to 10-cm soil depth increment (from the soil profile beneath the leaf litter layer) from each sampling site. Each composite sample must comprise five subsamples.

6) Licensees must assess the receiving soil as set out in Section 3 to confirm its suitability for the DFPL disposal method.

11.3 Disposal onto Forested Lands Disposal Requirements

7) Licensees must segregate cement returns from the drilling waste and manage them as set out in Section 7.

8) Licensees must isolate drillstem test fluids and any sections of the mud system that are contaminated with hydrocarbons and manage them by a different and appropriate method.

9) Licensees must either manage separated solids and cuttings by a different method (i.e., mix-bury-cover, landspreading, biodegradation) or send them to an approved waste management facility. If the drilling waste was originally tested as a total waste and the

volume of the separated solids and cuttings is less than 20 m^3, separate analysis is not required unless further information is needed to meet the requirements of the other disposal method.

10) Licensees must sample and analyze the drilling waste (i.e., fluids or total waste) for pH, EC, SAR, Na, and N (if the cumulative amount of N [NH_4-N, NO_3-N, NO_2-N] in additives/products added to the drilling mud or waste system exceeds 100 kg or is unknown) and use the results to calculate spread rates that will prevent the receiving soil from exceeding the endpoints for salts set out in Table 3.1.

11) Licensees must only use the DFPL disposal method for water-based drilling mud systems where the drilling waste (fluids or total waste)

    a) has a pH within the range of 6 to 10.5;

    b) has an EC that does not exceed 10 dS/m;

    c) contains no visible hydrocarbons, and no other hydrocarbon flags were encountered while the well was drilled;

    d) does not contain cumulative concentrations of metals from mud additives/products that exceed the values set out in Table 3.4 (another disposal option must be used if metal content is unknown); and

    e) does not contain any mud additives/products that were used in concentrations above the luminescent bacteria toxicity test pass threshold (EC50[15] $\geq$ 75 per cent).

12) Notwithstanding the requirements of 11(c), (d), and (e), licensees must store, sample, and test the drilling waste before proceeding with DFPL if

    a) a hydrocarbon flag was encountered during the drilling of the well:

        i) the concentration of each hydrocarbon component (BTEX and F1 to F4 fractions) in the drilling waste must be determined and used to calculate a spread rate such that the concentrations in the soil/waste mix do not exceed the endpoints set out in Table 3.2.

    b) fluid additives/mud products were used in concentrations exceeding the luminescent bacteria toxicity test pass threshold (EC50[15] $\geq$ 75 per cent) or for which toxicity data is unknown:

        i) the drilling waste must be tested for toxicity and found to be nontoxic (refer to Section 4.3 for toxicity assessment requirements).

    c) the cumulative concentration of metals (contributed by all fluid additives/mud products) in the drilling mud system exceeds the concentrations set out in Table 3.4, or if there is not enough fluid additives/mud products information to determine the metal concentrations in the drilling waste:

        i) the concentration of metals in the drilling waste must be determined and used to calculate spread rates such that the concentrations in the soil/waste mix do not exceed the endpoints set out in Table 3.4.

NOTE: Licensees can compensate for points (b) and (c) above by following the "generic mud system" protocol set out in Section 4.4.

13) Licensees must ensure that

a) the minimum drilling waste spread rate is not less than 10 m^3/ha (note that the calculated spread rate for a parameter decreases as the concentration of the parameter in the drilling waste increases);

b) the maximum drilling waste spread rate does not exceed 80 m^3/ha for summer or winter operations;

c) the drilling waste does not clump or pool on the land, migrate off the disposal area, or cause land erosion;

NOTE: To avoid physical issues such as pooling, erosion, and waste migration, the maximum application rates are the "actual maximum spray rates" that can be applied to the disposal area.

d) the sodium application rate does not exceed 250 kg/ha and the nitrogen application rate does not exceed 25 kg/ha; and

e) the solids application rate does not exceed 6 t/ha when spraying onto vegetated lands, and the DFPL does not smother or stress the vegetation (i.e., clumping or uneven application resulting in vegetation being coated with drilling waste).

14) If wishing to exceed the nitrogen application rate of 25 kg/ha, licensees must submit an application and obtain ERCB written approval for an alternative management method as set out in Section 19 of this directive. Information based on Section A2.3 of Appendix 2 must be provided to support the application.

15) If the drilling waste is treated, licensees must resample and reanalyze the drilling waste to determine the applicability of this method.

16) Licensees must mark the spray area prior to disposal. All stop and start points must be clearly flagged/marked. The flags are to remain in place until the entire disposal operation is complete. Once disposal operations are complete, the flags/markers must be removed.

11.4 Disposal onto Forested Public Lands Post-disposal Requirements

17) Licensees must conduct post-disposal sampling of the waste/soil mix and compare the results to the applicable soil endpoints set out in Section 3 if

a) the EC of the drilling waste exceeds 8 dS/m, the nitrogen loading rate exceeds 20 kg/ha, or the sodium loading rate exceeds 150 kg/ha—analyze for EC, SAR, Na and N (NH_4-N, NO_3-N, NO_2-N);

b) the concentrations of metals in the drilling waste exceed any of the concentrations set out in Table 3.5—analyze for metals; or

c) a hydrocarbon flag was encountered and the hydrocarbon concentrations in the drilling waste exceed the concentrations for any of the parameters listed in Table 3.3—analyze for BTEX and F1 to F4 hydrocarbon fractions.

Table 11.1. Summary of disposal onto forested Public Lands[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving soil • topsoil with EC < 2 dS/m, SAR < 4 Site • limited to forested Public Lands for which SRD has issued an MSL or LOC • slope must be less than 5% • 50 m setback from a water well • 100 m setback from a water body • 10 m setback from a road ditch or property line • minimum depth of 30 cm to mineral soil horizon • must not be open muskeg or areas where drilling waste could run off into ditches, natural drainage channels, or water bodies Waste • limited to nontoxic, water-based drilling wastes • segregate cement returns and drillstem fluids • separated solids or drill cuttings to be managed by another method	Fluids or total waste • pH between 6 and 10.5 • EC ≤ 10 dS/m • mud additives/ products used in concentrations below pass threshold level for luminescent bacteria toxicity test, or drilling waste passes toxicity test • maximum application rate: 80 m^3/ha (summer or winter) • minimum spread rate: 10 m^3/ha • maximum solids application rate for vegetated lands: 6 t/ha • if hydrocarbon flag encountered, analyze drilling waste and use BTEX and F1 to F4 hydrocarbon results to calculate spread rates to prevent exceedances of criteria in Table 3.2 • if cumulative concentrations of metals in mud additives/products exceed values in Table 3.4 or are unknown, analyze drilling waste for metals; use results to calculate spread rates	Soil/waste mix limited to a maximum increase of one unit beyond background soil EC and SAR, but not to exceed an EC of 2 dS/m or an SAR of 4 Maximum Na loading rate: 250 kg/ha Maximum N loading rate: 25 kg/ha Soil/waste mix must not exceed soil hydrocarbon and metal endpoints in Tables 3.2 and 3.4	Receiving soil • EC and SAR Fluids or total waste • pH, EC, SAR, Na, • N, if an unknown amount or an amount ≥100 kg N was added to the drilling mud or waste system • metals, if metals added to mud system in excess of concentrations in Table 3.4 or are unknown • hydrocarbons, if hydrocarbon flag encountered • toxicity, if toxicity data is unknown for any of the mud additives/products used in the drilling mud system or if concentrations used exceeded pass threshold for luminescent bacteria toxicity test Waste/soil mix (post-disposal) • EC, SAR, Na and N, if the drilling waste exceeds an EC of 8 dS/m, the N loading rate exceeds 20 kg/ha, or if the Na loading rate exceeds 150 kg/ha • metals, if concentrations in the drilling waste exceed concentrations listed in Table 3.5 • hydrocarbons, if concentrations in the drilling waste exceed concentrations listed in Table 3.3

[1] This table summarizes the DFPL requirements, but the details within the numbered requirements of Section 11 will be used for assessing compliance with the DFPL disposal method.

12 Pump-off

12.1 Introduction

The pump-off disposal method involves pumping the clear liquid portion of drilling wastes onto land (usually vegetated land) using irrigation equipment, such as a big gun, sprinkler, gated pipe, or perforated hose, or using water/vacuum trucks. Application rates must be calculated to ensure that the receiving soil meets the endpoints set out in Section 3 directly after the drilling waste is applied and without incorporating it into the soil.

While pump-off is normally an off-site management option, this does not preclude pumping off small volumes on the well site that generated the drilling waste or on a remote sump site, provided the drilling waste was stored on the remote sump site. Small volumes of clear fluids may be pumped onto well site access roads provided these locations are leased or owned by the licensee and landowner/department/agency written consent has been obtained. Pump-off disposal on pipeline-right-of-ways is limited to drilling waste resulting from directional drilling for construction of the associated pipeline

Refer to Table 12.1 for a summary of the requirements for the pump-off disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

12.2 Pump-off Receiving Soil Requirements

1) Licensees must only select land for the pump-off disposal method that

   a) is free of unique features that would lead to pooling, erosion, or migration of the drilling waste,

   b) is not within 10 m of a road ditch or property line,

   c) is not within 100 m of a water body, and

   d) is not within 50 m of a water well.

   NOTE: Licensees may, notwithstanding requirement 1(c) above, reduce the water body separation distance to 50 m if the water body is upgradient of the selected dipsoal area or if the landscape creates a physical barrier that would prevent the drilling waste from migrating towards the water body.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) Select one sampling site for each hectare of disposal area.

   b) Ensure each sampling site is a circular area with a 10 m radius and a centre precisely located and documented GPS [UTM], such as NAD83, along with bearing and metres from a fixed point.

   c) As a minimum, collect one composite sample from the 0- to 10-cm soil depth increment and one from the 10- to 30-cm soil depth increment from each sampling site. Each composite sample must comprise five subsamples.

3) Licensees must assess the receiving soil as set out in Section 3 to confirm its suitability for the pump-off disposal method.

4) Licensees must (except when the disposal is occurring on a well site, remote storage site, or an area of a pipeline right-of-way that has a disturbed surface) obtain written consent from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to Section 1.6) before beginning any landspray activities.

12.3 Pump-off Disposal Requirements

5) Licensees must only use the pump-off disposal method for the portions of water-based drilling wastes that qualify as clear liquids (i.e., do not contain any visible hydrocarbons and appear nonturbid when sampled from the discharge point; may be colourless or have natural colour or staining).

6) Licensees must sample and analyze the clear liquids for pH, EC, SAR, Na, and N (if any of the additives/products added to the drilling mud system or drilling waste contain any amount of N [NH_4-N, NO_3-N, NO_2-N] or if the N content is unknown) to ensure that the liquids

   a) have a pH between 6 and 8.5; if the pH is adjusted, it must be re-verified before pumping off; laboratory analysis is not required for a pH adjustment of less than 2 units;

   b) have an EC that does not exceed 10 dS/m;

   c) pass a luminescent bacteria toxicity test before disposal (refer to Section 4.3); if the initial toxicity assessment fails, but passes after being charcoal treated, the fluids must be analyzed for BTEX and F1 to F4 hydrocarbon fractions and the sum of the results must be less than 100 mg/L for pump-off to proceed; and

   d) can be pumped off without exceeding a sodium loading rate of 250 kg Na/ha and a nitrogen loading rate of 25 kg N/ha.

7) Licensees must not exceed an "actual" application rate of 1000 m^3/ha.

8) If wishing to exceed the nitrogen application rate of 25 kg/ha, licensees must submit an application and obtain ERCB approval for an alternative management method as set out in Section 19 of this directive; information based on Section A2.3 of Appendix 2 must be provided to support the application.

9) If the waste is treated, licensees must resample and reanalyze the waste to determine the applicability of this disposal method.

12.4 Pump-off Post-disposal Requirements

10) Licensees must conduct post-disposal sampling of the soil/waste mix and compare the results to the applicable soil endpoints set out in Section 3 if

   a) the EC of the clear liquid exceeds 5.0 dS/m—analyze for EC and SAR;

   b) the sodium loading rate exceeds 150 kg/ha—analyze for Na and SAR; or

   c) the nitrogen loading rate exceeds 20 kg/ha—analyze for N (NH_4-N, NO_3-N, NO_2-N).

Table 12.1. Summary of pump-off disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving soil • topsoil with EC < 2 dS/m, SAR < 4 Site • 50-m setback from a water well • 100-m setback from a water body • 10-m setback from a road ditch and property line • free of unique features that would lead to pooling, erosion, or migration of the drilling waste • landowner or Crown department/agency consent for disposal Waste • limited to clear liquid portion of water-based drilling waste • must pass a toxicity test	Clear liquids • pH between 6 and 8.5 • EC ≤ 10 dS/m • no visible hydrocarbons • if fails initial toxicity assessment, but passes after being charcoal treated, analyze for hydrocarbons; if total petroleum hydrocarbons > 100 mg/L, do not proceed with pump-off • application rate to not exceed 1000 m^3/ha • pump-off must not result in pooling, runoff, or land erosion	Soil/waste mix limited to a maximum increase of one unit beyond background soil EC and SAR, but not to exceed an EC of 2 dS/m and an SAR of 4 Maximum Na loading rate: 250 kg/ha Maximum N loading rate: 25 kg/ha Soil/waste mix must not exceed soil hydrocarbon and trace element endpoints in Tables 3.2 and 3.4	Receiving soil • EC and SAR Clear liquids • pH, EC, SAR, Na, and N (if any amount of N was added to the drilling mud or waste system or the N content is unknown) • toxicity assessment • hydrocarbons, if initial toxicity assessment fails, but passes after being charcoaled treated Waste/soil mix (post-disposal) • EC, SAR, Na, and N, if clear liquids exceed an EC of 5 dS/m, the N loading rate exceeds 20 kg/ha, or if the Na loading rate exceeds 150 kg/ha

[1] This table summarizes the pump-off requirements, but the details within the numbered requirements of Section 12 will be used for assessing compliance with the pump-off disposal method.

13 Mix-Bury-Cover

13.1 Introduction

The mix-bury-cover (MBC) disposal method involves mixing nonhydrocarbon-based drilling waste solids or total waste with subsoils on the well site, pipeline-right-of-way (provided the surface of the right-of-way is disturbed as identified in Section 8 and the drilling waste is from the construction of the associated pipeline), or remote drilling waste storage site (provided the drilling waste was stored at the remote site), at a depth profile of 1 m to 1.5 m, or deeper than 1.5 m, to form a stabilized waste/soil mass that resides below the major rooting zone.

Typical MBC methods are

- to mix waste and subsoil in the sump and cover;
- to mix waste from the sump and subsoil on the surface, then put the mixture back in the sump and cover;
- to bail the waste from the sump onto the lease surface, mix with the subsoil, and bury when filling in a cut; or
- to spread the waste on the lease surface and allow it to dry; put the waste back into the sump, then mix and cover.

Licensees can use on-site management techniques (e.g., dewatering systems, shakers, solids control) to pre-treat drilling waste before using this method. Refer to Section 19 regarding ERCB approval for use of new technologies or treatment methods.

Refer to Table 13.1 for a summary of the requirements for the MBC disposal method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

13.2 Mix-Bury-Cover Receiving Soil Requirements

1) Licensees must conduct MBC disposals within deeper subsoils (i.e., at a depth profile between 1 m and 1.5 m or deeper than 1.5 m) on the well site, pipeline right-of-way, or remote drilling waste storage site.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) for disposal areas that are 3000 m^2 or less, collect a minimum of one composite sample comprised of five subsampes;

   b) for disposal areas that exceed 3000 m^2, divide the area into equal plots that are no larger than 3000 m^2 and collect one composite sample comprised of five subsamples for each plot;

   c) collect each subsample at the soil profile depth for incorporation of the drilling waste (excluding clean fill/cap);

   d) ensure the soil/waste mix sample is not diluted with soil from above or below the mix depth.

3) Licensees must assess the receiving soil as set out in Section 3 to confirm its suitability for the mix-bury-cover disposal method. If the drilling waste contains nitrogen or if the nitrogen content is unknown, licensees must also determine whether the receiving soil is coarse-grained (median grain size is greater than 75 microns) or fine-grained (median grain size is 75 microns or less).

13.3 Mix-Bury-Cover Disposal Requirements

4) Licensees must not manage drilling wastes resulting from hydrocarbon-based mud systems using the MBC method unless the waste has undergone biodegradation (refer to Section 15).

5) Licensees must sample the drilling waste by taking either

   a) a total waste (fluids and solids) sample, if both phases are being managed by MBC, or

   b) a solids sample, if only the solid phase is being managed by MBC.

6) Licensees must have the sample analyzed for the following parameters and use the results to determine the soil/waste mix ratio that will prevent the receiving soil from exceeding the soil endpoints set out in Section 3:

   a) pH, EC, SAR, and Na;

   b) nitrogen (N), if the additives/products used to formulate the drilling mud system or added to the drilling waste contain any amount of N (NH_4-N, NO_3-N, NO_2-N) or if the N content of any of the additives/products used to formulate the drilling mud system or added to the drilling waste is unknown;

   c) metals, if the cumulative concentration of metals in mud additives/products added to the drilling mud system exceeds the values set out in Table 3.4, or if metal content of the mud additives/product is unknown;

   d) hydrocarbons (i.e., BTEX and F1 to F4 hydrocarbon fractions), if a hydrocarbon flag was encountered; and

   e) toxicity, if mud additives/products were used in concentrations above the luminescent bacteria toxicity test pass threshold ($EC50|15| \geq 75$ per cent), or if toxicity data is unknown. The sample must pass the toxicity test; for those drilling wastes that only pass the toxicity test after being charcoal treated, disposal may only proceed if hydrocarbons are the likely source of toxicity.

7) Licensees must mix the subsoil and drilling waste at a ratio of at least three parts subsoil to one part drilling waste. In addition,

   a) licensees must use predictive lab mixes to determine the soil/waste mix ratio for drilling wastes with an EC of 10 dS/m or more and an Na concentration of 3000 mg/L or greater (in saturated paste extract or filtrate from oversaturated sample).

      (Refer to Appendix 2, Section A2.4 for the lab protocol for mixing drilling waste with receiving soil.)

b) licensees must not proceed with MBC operations when the predictive lab or calculated mix ratios exceed seven parts soil to one part waste (alternative options include treating and retesting the waste to verify the suitability of the method, or using a different disposal method).

8) Licensees must not exceed a soil N endpoint (i.e., concentration of N [NH_4-N, NO_3-N, NO_2-N] in the soil/waste mix) of 10 mg/kg for coarse soils or 40 mg/kg for fine soils.

9) Licensees must cover the subsoil/waste mixture with a minimum of 1 m of clean fill. The EC and SAR of the clean fill must meet AEW *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010) for the applicable soil rating category and depth.

NOTE: The use of naturally saline subsoils as the fill material may introduce unacceptable levels of salts to the rooting zone and may interfere with the final reclamation process and objective to restore the site to equivalent land capability.

10) Licensees must not conduct the MBC disposal within 10 m of an on-site rig water supply well. Should there be any concerns about protection of the wellhead during the MBC operation, the minimum 10-m distance must be appropriately increased. The soil/waste mix outer boundary must be at least 10 m from the rig water well.

11) If the waste is treated, licensees must resample and reanalyze the waste to determine the applicability of this disposal method.

12) If the site has previously been used for disposal, licensees must only proceed with the MBC disposal if

a) the MBC disposal occurs on an area of the site not previously used for drilling waste disposal, and all MBC requirements are met; and

b) the use of the site for drilling waste management/multiple disposals has not exceeded a duration of five years, and any reuse of a sump or alternative storage system has followed the requirements set out in Section 6.6.

13.4 Mix-Bury-Cover Post-disposal Requirements

13) Licensees must conduct post-disposal sampling of the soil/waste mix and compare the results to the applicable soil endpoints set out in Section 3 if

a) the EC of the drilling waste exceeds 10 dS/m or the Na content of the drilling waste exceeds 3000 mg/L (in saturated paste extract or filtrate from oversaturated sample)—analyze for EC, SAR, and Na;

b) the concentrations of metals in the drilling waste exceed the concentrations set out in Table 3.5—analyze for metals;

c) the concentration of hydrocarbons in the drilling waste exceeds the concentration for any of the parameters listed in Table 3.3—analyze for BTEX and F1 to F4 hydrocarbon fractions; or

d) the nitrogen concentration in the drilling waste (wet weight) is 6 mg/kg or more for disposals in coarse soils or 120 mg/kg or more for disposals in fine soils—analyze for N (NH_4-N, NO_3-N, NO_2-N).

Table 13.1. Summary of mix-bury-cover disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving subsoil • between 1 m and 1.5 m: EC ≤ 5 dS/m, SAR ≤ 8 • deeper than 1.5 m: no EC or SAR limits • fine-grained soil Site • 10-m setback distance between MBC operation and an on-site water well • restricted to well site, remote sump site, or disturbed pipeline right-of-way. Waste • water-based drilling wastes or biodegraded hydrocarbon-based drilling wastes • solids or total waste • must pass a toxicity assessment if a hydrocarbon flag was encountered, or if mud additives/products were used in concentrations exceeding luminescent bacteria toxicity test threshold, or if toxicity data are unknown	Solids or total waste • if additives/products added to the mud/waste system contain any amount of N or if the N content was unknown, analyze the drilling waste for N and use the results to calculate spread rates • if hydrocarbon flag encountered, analyze and use BTEX and F1 to F4 hydrocarbon results to calculate spread rates to prevent exceedances of criteria in Table 3.2 • mud additives/products used in concentrations below the pass threshold level for luminescent bacteria toxicity test, or drilling waste passes toxicity test • if cumulative concentrations of metals in mud additives/products exceed values in Table 3.4 or are unknown, analyze drilling waste for metals; use results to calculate spread rates Subsoil/waste mixture must be at least three parts subsoil to one part drilling waste, but cannot exceed seven parts subsoil to one part drilling waste Lab mixes must be used to determine soil/waste mix ratio when drilling waste EC ≥ 10 dS/m or Na ≥ 3000 mg/L (saturated paste extract or filtrate from oversaturated waste)	Soil/waste mix limited to a maximum increase of • two units for EC and four units for SAR beyond background soil conditions for MBC depths between 1 m and 1.5 m • three units for EC and six units for SAR for MBC depths at or below 1.5 m Soil/waste mix limited to a maximum N concentration of • 10 mg/kg for coarse soil • 40 mg/kg for fine soil Soil/waste mix must not exceed soil hydrocarbon and metals endpoints in Tables 3.2 and 3.4 A minimum of 1 m of clean subsoil must cover soil/waste mixture	Receiving soil • EC and SAR Waste (solids or total waste) • pH, EC, SAR, Na • N, if additives/products added to the drilling mud/waste system contain any amount of N or if N content was unknown • metals, if concentrations exceeding Table 3.4 limits were added to the drilling mud system or if the metal content of additives/products is not known • hydrocarbons, if a hydrocarbon flag was encountered • toxicity, if toxicity data are unknown for any of the mud additives/ products used in the drilling mud system or if concentrations used exceeded pass threshold for luminescent bacteria toxicity test Waste/soil mix (post-disposal) • EC, SAR, and Na, if drilling waste EC > 10 dS/m or Na > 3000 mg/L (saturated paste extract or filtrate from oversaturated waste) • metals, if concentrations in drilling waste exceed concentrations listed in Table 3.5 • hydrocarbons, if concentrations in the drilling waste exceed concentrations listed in Table 3.3 • N, if the nitrogen concentration in the drilling waste (wet weight) is ≥6 mg/kg for disposals in coarse soil or ≥120 mg/kg for disposals in fine soil.

[1] This table summarizes the MBC requirements, but the details within the numbered requirements of Section 13 will be used for assessing compliance with the MBC disposal method.

14 Landspreading

14.1 Introduction

The landspreading method involves spreading water-based drilling waste on the shallow subsoil of a well site, pipeline-right-of-way (provided the surface of the right-of-way is disturbed as identified in Section 8 and the drilling waste is from the construction of the associated pipeline), or remote drilling waste storage site (provided the drilling waste was stored on the remote site) and incorporating it into the shallow subsoil.

Typical landspreading methods are

- to rip the subsoil and spread (squeeze) and incorporate the waste from the sump on site; and
- to spread (squeeze) the waste from the sump on site, dry it, and then incorporate it into the shallow subsoil.

Refer to Table 14.1 for a summary of the requirements for the landspreading method, but note that the details within the numbered requirements will be used for assessing compliance with the requirements.

14.2 Landspreading Receiving Soil Requirements

1) Licensees must conduct landspreading within shallow subsoils (i.e., maximum depth profile of 1 m) on the well site, pipeline right-of-way, or remote drilling waste storage site.

2) Licensees must collect samples for assessing pre- and post-disposal (where applicable) soil conditions as follows:

   a) for disposal areas that are 3000 m^2 or less, collect a minimum of one composite sample comprised of five subsampes;

   b) for disposal areas that exceed 3000 m^2, divide the area into equal plots that are no larger than 3000 m^2 and collect one composite sample comprised of five subsamples for each plot;

   c) collect each subsample from the 0- to 30-cm soil depth profile or the drilling waste depth incorporation, whichever is less;

   d) ensure the soil/waste mix sample is not diluted with soil from below the mix depth.

3) Licensees must assess the receiving soil as set out in Section 3 to confirm its suitability for the landspreading disposal method

14.3 Landspreading Disposal Requirements

4) Licensees must not use landspreading for drilling wastes resulting from hydrocarbon-based mud systems, unless the drilling waste has undergone biodegradation (refer to Section 15).

5) Licensees must sample the drilling waste by taking either

   a) a total waste (fluids and solids) sample, if both phases are being managed by landspreading, or

   b) a solids sample, if only the solid phase is being managed by landspreading.

6) Licensees must analyze the sample for the following parameters and use the results to determine the soil/waste mix ratio that will prevent the receiving soil from exceeding the soil endpoints set out in Section 3:

   a) pH, EC, SAR, Na;

   b) nitrogen (N), if the cumulative mass of N (NH_4-N, NO_3-N, NO_2-N) in additives/products added to the drilling mud system or drilling waste exceeds 300 kg or is unknown;

   c) metals, if the cumulative concentration of metals in mud additives/products added to the drilling mud system exceeds the values set out in Table 3.4 or if metal content of the mud additives/products is unknown;

   d) hydrocarbons (i.e., BTEX and F1 to F4 hydrocarbon components), if a hydrocarbon flag was encountered; and

   e) toxicity, if mud additives/products were used in concentrations above the luminescent bacteria toxicity test pass threshold ($EC50[15] \geq 75$ per cent) or if toxicity data is unknown. The sample must pass the toxicity test; for those drilling wastes that only pass the toxicity test after being charcoal treated, disposal may only proceed if hydrocarbons are the likely source of toxicity (see Section 4.3).

7) Licensees must ensure that the pH of drilling waste being landspread is not less than 6 or greater than 10.5.

8) Licensees must mix the subsoil and drilling waste at a ratio of at least three parts subsoil to one part drilling waste. In addition,

   a) licensees must use predictive lab mixes to determine the soil/waste mix ratio if drilling wastes have an EC of 8 dS/m or more or an Na concentration of 2000 mg/L or greater (in saturated paste extract or filtrate from oversaturated waste), or if the landspreading is to occur on soil within the fair soil rating category (refer to Table 3.1); and

      (Refer to Appendix 2, Section A2.4 for the lab protocol for mixing drilling waste with receiving soils.)

   b) licensees must not proceed with landspreading operations when the predictive lab or calculated mix ratios exceed seven parts soil to one part waste (alternative options include treating and retesting the waste to verify the suitability of the method, or using a different disposal method).

9) Licensees must not exceed a waste application rate of 1000 m^3/ha or a thickness of 10 cm.

10) If the landspreading is to occur on soil within the good soil rating category (refer to Table 3.1), licensees must ensure that the Na application rate does not exceed 500 kg/ha. This value must be prorated to the applicable mass of Na based on the actual area used for the lands predisposal (e.g., if the disposal area is 0.1 ha, then the mass of Na allowed is 50 kg; 500 kg Na/ha x 0.1 ha = 50 kg Na).

11) Licensees must not exceed a N loading of 400 kg N/ha within the landspread disposal area; this value must be prorated to applicable mass of N based on the actual area used for the landspread disposal (e.g., if the disposal area is 0.1 ha, then the mass of N allowed is 40 kg; 400 kg N/ha x 0.1 ha = 40 kg N).

12) Licensees must not conduct the landspread disposal within 10 m of an on-site rig water supply well. Should there be any concerns about protection of the wellhead during the landspreading operation, the minimum 10 m distance must be appropriately increased. The soil/waste mix outer boundary must be at least 10 m from the rig water well.

13) If the waste is treated, licensees must resample and reanalyze the waste to determine the applicability of this disposal method.

14) If the site has previously been used for drilling waste disposal, licensees must only proceed with the landspread disposal if

    a) the landspreading occurs on an area of the site not previously used for drilling waste disposal; and

    b) the use of the site for drilling waste management/multiple disposals has not exceeded a duration of five years and any reuse of a sump or alternative storage system has followed the requirements set out in Section 6.6.

14.4 Landspreading Post-disposal Requirements

15) Licensees must conduct post-disposal sampling of the soil/waste mix and compare the results to the applicable soil endpoints set out in Section 3 if

    a) the EC of the drilling waste exceeds 8 dS/m or the Na content of the drilling waste exceeds 2000 mg/L (in saturated paste extract or filtrate from oversaturated waste)—analyze for EC, SAR, and Na;

    b) the concentrations of metals in the drilling waste exceed the concentrations set out in Table 3.5—analyze for metals;

    c) the concentration of hydrocarbons in the drilling waste exceeds the concentration for any of the parameters listed in Table 3.3—analyze for BTEX and F1 to F4 hydrocarbon fractions; or

    d) the nitrogen loading rate exceeds 300 kg/ha (pro-rated to the mass of N based on the actual area used for the landspread disposal)—analyze for N (NH_4-N, NO_3-N, NO_2-N).

Table 14.1 Summary of landspreading disposal method[1]

Pre-application conditions	Waste application rates/limits	Post-application conditions	Testing requirements
Receiving subsoil • shallow subsoil to 1 m in depth: EC ≤ 3 dS/m, SAR ≤ 4 for soils in good category; EC of 3 to 5 dS/m, SAR of 4 to 8 for soils in fair category Site • 10-m setback distance between landspread operation and an on-site water well • restricted to well site, remote sump site, or disturbed pipeline right-of-way Waste • water-based drilling wastes or biodegraded hydrocarbon-based drilling wastes • solids or total waste • must pass a toxicity assessment if a hydrocarbon flag was encountered, or if mud additives/products were used in concentrations exceeding the luminescent bacteria toxicity test threshold, or if toxicity data are unknown	Solids or total waste • pH between 6 and 10.5 • N: < 400 kg N/ha pro-rated to kg N/ha of actual disposal area • if hydrocarbon flag encountered, analyze drilling waste and use BTEX and F1 to F4 hydrocarbon results to calculate spread rates to prevent exceedances of criteria in Table 3.2 • mud additives/products used in concentrations below the pass threshold level for luminescent bacteria toxicity test, or drilling waste passes toxicity test • if cumulative concentrations of metals in mud additives/products exceed values in Table 3.4 or are unknown, analyze drilling waste for metals; use results to calculate spread rates Subsoil/waste mixture must be at least three parts subsoil to one part drilling waste, but cannot exceed seven parts subsoil to one part drilling waste Waste application rate must not exceed 1000 m^3/ha or a thickness of 10 cm Lab mixes must be used to determine soil/waste mix ratio when drilling waste EC ≥ 8 dS/m or Na ≥ 2000 mg/L (saturated paste extract or filtrate from oversaturated waste), or if occurring on soils within the fair soil rating category	Soil/waste mix limited to a maximum increase of • two units for EC and three units for SAR beyond background soil conditions, but not to exceed EC of 3 dS/m or SAR of 6 when background soil EC < 3 dS/m and SAR < 4 • one unit for EC and two units for SAR beyond background soil conditions when background soil EC is 3 to 5 dS/m and SAR is 4 to 8 Maximum Na loading rate: 500 kg/ha when background soil EC < 3 dS/m and SAR < 4 Maximum N loading rate: 400 kg/ha Soil/waste mix must not exceed soil hydrocarbon and metals in Tables 3.2 and 3.4	Receiving soil • EC and SAR Waste (solids or total waste) • pH, EC, SAR, Na • N, if an unknown amount or an amount ≥300 kg of N was added to the mud or waste system • metals, if concentrations exceeding Table 3.4 limits were added to the drilling mud system or if the metal content of additives/products is not known • toxicity, if toxicity data are unknown for any of the mud additives/ products used in the drilling mud system or if concentrations used exceeded pass threshold for luminescent bacteria toxicity test • hydrocarbons, if a hydrocarbon flag was encountered Waste/soil mix (post-disposal) • EC, SAR, and Na, if drilling waste EC > 8 dS/m or Na > 2000 mg/L (saturated paste extract or filtrate from oversaturated waste) • metals, if concentrations in drilling waste exceed concentrations listed in Table 3.5 • hydrocarbons, if concentrations in the drilling waste exceed concentrations listed in Table 3.3 • N, if the nitrogen loading rate exeeds 300 kg/ha

[1] This table summarizes the landspreading requirements, but the details within the numbered requirements of Section 14 will be used for assessing compliance with the landspreading disposal method.

15 Biodegradation

15.1 Introduction

The biodegradation disposal method involves the reduction of organic constituents in the drilling waste by a microbial process. Success involves optimizing conditions for microbial activity, such as temperature, pH, and moisture, nutrient, and oxygen content. The organic constituents must be biodegradable and not toxic to the microorganisms.

Biodegradation is often used to manage drilling wastes contaminated with formation hydrocarbons or hydrocarbon-based drilling wastes. It can also be used to manage drilling wastes that contain other organics (e.g., starches, alcohols, and formates). The most common biodegradation techniques are land treatment and treatment within a contained system, such as in an impermeable cell structure or on an impermeable barrier (i.e., natural clay, compacted clay, or synthetic liner).

The following sections set out the requirements to biodegrade hydrocarbon-contaminated or hydrocarbon-based drilling wastes.

1) Licensees must apply to the ERCB and obtain ERCB written approval to either alter the requirements or biodegrade drilling wastes containing other organics. The application must contain scientific rationale that supports the changed requirements or that explains the biodegradation of the nonhydrocarbon organics (e.g., description of the mechanism for biodegradation, including any intermediate compounds and resulting breakdown compounds, as well as the fate and toxicity of the intermediate and resulting compounds in the environment). The application must also address the design and operation of the proposed biodegradation technique and site characterization (refer to Section 19).

15.2 Drilling Waste and Site Characterization Requirements

Licensees must appropriately characterize drilling waste to determine whether the organic constituents are susceptible to biodegradation and whether there are recalcitrant constituents within the drilling waste (e.g., salts, metals) that must also be managed. The biodegradation of petroleum hydrocarbon is typically most successful when it consists of low molecular weight aromatics and aliphatics. Petroleum hydrocarbons containing a large fraction of asphaltenes or nitrogen- and sulphur-rich heterocyclic compounds may take a long time to degrade and may even produce toxic intermediates.

An assessment, such as a hydrocarbon fractionation characterization or treatability study, may be useful to predict biodegradation success in situations where an alternative organic-based drilling mud was used or where higher molecular weight hydrocarbons were added to the mud system or infiltrated the drilling mud from the formation. An assessment may prevent future remedial actions, especially if land treatment was the chosen biodegradation method. Any biodegradation technique must not compromise future land capability and the ability to meet reclamation certification requirements.

When biodegrading drilling waste, licensees must ensure that the following requirements are met:

2) Irrespective of the biodegradation technique chosen, licensees must take a representative sample of the raw drilling waste and analyze it for the following

    a) hydrocarbons (i.e., BTEX and F1 to F4 hydrocarbon fractions);

NOTE: Refer to Section A3.3 of Appendix 3 for information about alternative methods of determining extractable hydrocarbons, which can be equated to the F2 to F4 hydrocarbon fractions in drilling wastes.

b) salinity (EC, SAR) and total mineral nitrogen (NH_4^+, NO_2^-, and NO_3^-);

c) pH;

d) major ions (Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, NH_4^+, NO_2^-, NO_3^-, SO_4^{2-}, PO_4^{3-}); and

e) metals, if the cumulative concentrations of metals in the mud additives/products added to the drilling mud exceed the values set out in Table 3.4 or if the metal content of the mud additives/products is not known.

3) Before constructing the biodegradation area, licensees must prepare the site following typical well site and soil conservation practices. The biodegradation site must be located so that

a) drainage ways and areas subject to seasonal flooding are avoided;

b) it is at least 100 m away from a water body and 50 m away from a water well; and

c) there is at least 10 m between an on-site rig water supply well and the area used for biodegradation.

4) If the biodegradation site is remote from the well site that generated the drilling waste, licensees must obtain a written agreement (e.g., surface lease or right of entry agreement or a disposition under the *Public Lands Act*) from the landowner or department/agency managing the land on behalf of the provincial or federal Crown (refer to Section 1.6). In addition,

a) Licensees must have signage at the site entrance identifying the legal land location (LSD), the licensee, the well licence to which the site is linked (see point [b] below), and a 24-hour emergency phone number. The site must be secured so that it is not a public hazard (with measures to prevent public or animals from accessing the drilling waste treatment area).

b) The biodegradation site must be tied back (i.e., link) to the well licence of the well that generated the drilling waste. Where more than one well contributes to the waste being biodegraded, the biodegradation site must be tied back to the well licence that first contributed drilling waste.

5) Licensees must determine background soil conditions before beginning biodegradation operations. Sampling must, as a minimum, consist of the following:

a) Divide each hectare of land comprising a biodegradation area into four equal plots. For biodegradation sites that are less than 1 ha in size, divide the sites into equal plots that are no more than ¼ ha (2500 m^2) in size. Depending on the treatment method, take the following samples from each plot:

i) land treatment method

- combine a minimum of five soil samples from a 0- to 15-cm depth, or from the treatment zone (depth of incorporation), to form one composite sample; and
- combine a minimum of five soil samples from a 15- to 45-cm depth, or from the soil profile for 30 cm directly below the treatment or incorporation zone, to form one composite sample.

ii) biodegradation in a contained system

- combine a minimum of five soil samples from a 0- to 30-cm depth to form one composite sample; and
- combine a minimum of five soil samples from a 30- to 60-cm depth to form one composite sample.

b) Analyze each sample for

i) pH,

ii) salinity (EC, SAR) and total mineral nitrogen,

iii) major ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, NH_4^{+}, NO_2^{-}, NO_3^{-}, SO_4^{2-}, PO_4^{3-}),

iv) median grain size, per cent clay, per cent sand, per cent fines, plasticity index (PI), and liquid limit (LL), and

v) metals as listed in Table 3.4.

c) Analyze a discrete soil sample for each depth profile set out in 5(a)(i) or (ii) above for BTEX and hydrocarbon fractions F1 through F4, unless there is sufficient site information to substantiate the absence of hydrocarbons in the soil (e.g., the area was previously undisturbed and is unlikely to be subject to contaminant migration from other areas of the site or from off-site sources).

6) Upon closure, licensees must re-evaluate soil conditions of the biodegradation site as follows:

a) Sample and analyze each plot as set out in requirements 5(a), (b), and (c) above, and depending on treatment method, also do the following sampling and analysis for each plot:

i) land treatment method

- take a minimum of one soil sample (not composited) for each depth (0 to 15 cm or treatment zone, and 15 to 45 cm or soil profile for 30 cm below the treatment zone), and analyze for BTEX and hydrocarbon fractions F1 to F4.

ii) biodegradation in a contained system

- take a minimum of one sample (not composited) for each depth (0 to 30 cm and 30 to 60 cm), and analyze for BTEX and hydrocarbon fractions F1 to F4.

b) If there is evidence of contamination in the deeper soil sample (15 to 45 cm for land treatment and 30 to 60 cm for biodegradation in a contained system), sample at

30-cm intervals, and analyze the samples following the protocol set out in requirements 5(a), 5(b), and 6(a) above, until the extent of contamination has been delineated. The contaminants must be remediated; then the site must be resampled.

The above are minimum requirements to establish background and closure soil conditions. It may be prudent to determine background conditions for the 45 to 75 cm depth for land treatment and the 60 to 90 cm depth for biodegradation in a contained system to prevent the use of sites that have existing contamination concerns.

7) Licensees must close sites used to biodegrade drilling waste within five years of the date that the biodegradation commenced. Upon completion of the biodegradation activity, the site must not exceed the soil quality endpoints set out in Section 3 (for salinity endpoints, refer to the criteria applicable to land treatment in Table 3.1).

8) In addition to meeting the soil quality endpoints, licensees must ensure that the closure of a remote biodegradation site (i.e., not on the well site) includes site reclamation. Licensees must obtain documentation from the appropriate department/agency indicating that the biodegradation site has been reclaimed and meets equivalent land capability as identified in Section 1.7 (i.e., reclamation certificates from AEW or SRD for sites defined as specified lands), and make it available to the ERCB upon request.

9) Licensees must electronically submit a notification to the ERCB at least 30 days before the beginning of the biodegradation activity. The notification must include

   a) the licensee name and business associate (BA) code;

   b) the well licence number and UWI of the well that generated the drilling waste, or the legal land location of the remote sump/storage system that contains the drilling waste to be biodegraded; the well licences of all of the wells that contributed to the drilling waste; and the well licence and UWI to which the remote sump/storage system and biodegradation site will be linked (i.e., the first well that contributed drilling waste);

   c) the legal land location of the biodegradation site, and confirmation, if required, that written landowner/department/agency consent has been obtained for the activity;

   d) the volume and type of drilling waste to be biodegraded;

   e) the type of biodegradation method (e.g., land treatment, biodegradation in a contained system);

   f) the commencement date for the biodegradation activity; and

   g) licensee commitment that all applicable requirements in Section 15 will be adhered to.

10) Licensees must electronically submit the notification to the ERCB in .pdf as an e-mail attachment as follows:

   a) E-mail the notification to Directive050@ercb.ca.

   b) Ensure that the attachment file name identifies it as a drilling waste biodegradation notification, contains the applicable well licence number and the UWI, and is formatted as DW_License#_UWI (e.g., BiodegradationDW_0123456_00~12-14-025-12W4~0).

c) Ensure that the subject field of the e-mail contains the file name.

NOTE: The ERCB will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliance event in accordance with *Directive 019*.

11) Licensees must file a second notification following the directions in requirement 10 above if the biodegradation site cannot be closed within five years. The notification must describe the biodegradation process used and the circumstances that impeded it, the amount of biodegradation that has occurred, the expected additional time needed to achieve closure endpoints, and the rationale supporting how extending the biodegradation duration would result in meeting applicable endpoints, taking into consideration the circumstances that impeded the process.

Where the biodegradation operation is on a site remote from the well site, the ERCB will assess the information submitted in the notification to determine if the licensee must undergo the approval process for an oilfield waste management facility.

15.3 Biodegradation of Drilling Waste by Land Treatment

15.3.1 Method Description

Land treatment involves applying the drilling waste from one well or one waste set (i.e., contents of a remote sump that only received drilling waste from one licensee's drilling program over one drilling season) to a dedicated parcel of land and cultivating it into the receiving subsoil, where the inherent soil processes biodegrade, transform, and assimilate the waste constituents.

Land treatment may be conducted from the well site or on a site remote from the well site. Drilling waste managed by land treatment becomes assimilated within the soil in which it was mixed. To maximize the success of land treatment and to minimize soil and environmental damage, the application rate and incorporation depth of the drilling waste is limited.

The method requires tillage and application of nutrients to break down the petroleum hydrocarbon in the drilling waste. Small amounts of amendments (e.g., nutrient, organic) may be added to enhance the biodegradation process. Aeration materials (e.g., wood chips, sawdust, straw) may be used in limited quantities (less than 10 per cent of the drilling waste volume), but excessive volumes of these materials may lead to site reclamation challenges. Sampling and analyses are necessary to monitor the progress of biodegradation.

15.3.2 Design and Operation

12) Licensees must select a land treatment site that is relatively level and does not have a slope that exceeds 3 per cent

13) Licensees must limit the receiving soil, which is often referred to as the treatment zone, to shallow subsoils (to a maximum depth profile of 1 m) that are in the good or fair soil rating category as set out in Table 3.1.

14) Licensees must ensure that the receiving soil or treatment zone (which is typically 15 cm in depth) has

a) clay content greater than 15 per cent, a sand content less than 50 per cent, and a texture that will allow contaminants within the drilling waste to be effectively mixed with the soil, yet retained within the treatment zone, and

b) pH within the range of 6 to 8.5.

15) Licensees must ensure that the maximum depth of the treatment zone is at least 1 m above the saturated zone.

16) For groundwater protection, licensees must ensure that the soil for 30 cm below the treatment zone is of limited permeability and has a clay content (i.e., particle size of 0.002 mm or smaller as determined by hydrometer method) of at least 20 per cent, a fines content (defined as dry weight percentage passing the No. 200 sieve) of at least 50 per cent, a PI equal to or greater than 10, and an LL equal to or greater than 30.

17) Licensees must ensure that the depth of waste incorporation into the receiving soil does not exceed that of normal cultivation equipment, typically 15 cm.

18) Licensees must mix the drilling waste into the receiving soil at a mix ratio of one part drilling waste to a minimum of three parts soil by volume. Mix ratios and amendments must be managed to ensure that the treatment area can be restored to equivalent land capability.

19) Licensees must ensure that the receiving soil is not saturated with water, covered with ice or snow, or frozen when the drilling waste is being applied.

20) After mixing the drilling waste with the receiving soil, licensees must ensure that the treatment zone meets the following criteria:

a) metal concentrations must not exceed the limits listed in Table 3.4 or the background concentrations for the receiving soil if any background soil metal concentrations exceed the limits in Table 3.4;

b) EC and SAR values must not exceed the maximum allowable increase from background values or the maximum EC and SAR values for the applicable soil horizon, depth, and rating category, as set out in Table 3.1; and

c) the total petroleum hydrocarbon concentration (e.g., sum of BTEX and F1 to F4 hydrocarbon fractions) must not exceed 2 per cent by mass.

21) Licensees must ensure that the predicted time to reduce the petroleum hydrocarbon content in the treatment zone to meet closure criteria (i.e., the endpoints set out in Table 3.2) does not exceed five years.

22) Licensees must berm the land treatment area (minimum height of 15 cm) to allow any generated leachate to collect and to prevent the run-on of surface waters. Collected leachate can be

a) irrigated over the land treatment area, provided it does not hinder the biodegradation process or create a soil quality problem,

b) managed following the pump-off disposal option set out in Section 11, or

c) injected down an approved disposal well.

23) Licensees may remove the berms after one year, but one of the requirements below must be met:

a) A 1:1 extract of treatment zone material with water passes a luminescent bacteria toxicity test.

b) The leachate collected from the land treatment area (or ponded water collected within the bermed area) for three consecutive but independent events that span 12 months has an extractable hydrocarbon (F2 to F4) content that does not exceed 15 mg/L and that passes a luminescent bacteria toxicity test. A minimum sample size of 1 L must be collected for each event.

The need for berms must be re-evaluated if amendments or other materials are added to the treatment site.

24) Licensees must work the land treatment area (e.g., disked, mixed) at least once a year during the active biodegradation period, unless alternative arrangements have been approved by the ERCB.

15.4 Biodegradation of Drilling Wastes in a Contained System

15.4.1 Method Description

Biodegradation of drilling waste in a contained system is the process where drilling waste is biodegraded in a contained and controlled environment, such as in an impermeable cell or on an impermeable barrier. This technique may be of particular interest when

- site conditions are not suitable for land treatment;
- the volume of drilling waste precludes the application rate for land treatment;
- biodegradation of the organic constituent is an intermediate step to make the drilling waste suitable for another treatment or disposal option;
- there is a desire to use the contained system to leach and collect water-soluble contaminants from the drilling waste in addition to biodegradation; or
- the drilling waste is intended to be used as a by-product, provided all the applicable soil quality endpoints have been met and the specific use of the by-product has been approved by the ERCB.

Because the process is conducted in a contained system, there is no upper limit on contaminants, including the hydrocarbon or other organic constituent concentration. Small amounts of amendments (e.g., nutrient, organic) may be added to these systems to enhance the biodegradation process. Aeration materials (e.g., wood chips, sawdust, straw) may be used in limited quantities (less than 10 per cent of the drilling waste volume), but excessive volumes of these materials leads to their use as bulking agents, which increases waste volume and creates challenges for the final disposition of the biodegraded or partially biodegraded material. If biodegradation in a contained system is being conducted as a pretreatment, the final analysis from this process can be used as the waste characterization information for the next management option.

25) Licensees must use the biodegradation containment system only once; licensees wishing to construct a containment system for repeat biodegradation operations must have it

approved as an oilfield waste management facility, pursuant to the requirements and application process set out in *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry.*

15.4.2 Design and Operation

26) Licensees must locate and construct the containment system to

a) have effective surface water run-on controls that will prevent the flow of surface water into the containment system;

b) provide a barrier of limited permeability that will not allow contaminants to migrate beyond the walls and base of the containment system; the barrier must consist of

i. a prepared lease surface made by compacting the existing soil of the lease, provided that to a minimum depth of 30 cm the soil has a minimum clay content of 20 per cent, minimum fines content of 50 per cent, PI of 10, and LL of 30; this option is limited to situations where the drilling waste is minimally contaminated or has been mixed with an adsorbent material and where

- total petroleum hydrocarbon concentration (i.e., sum of BTEX and F1 to F4 hydrocarbon components) of the drilling waste or adsorbed drilling waste does not exceed 2 per cent by mass; and
- an extract (obtained from the saturated paste filtrate method) of a representative sample of the drilling waste or adsorbed drilling waste mix has EC and SAR values of no more than two and three units, respectively, above background soil values; or

ii. a compacted clay, natural, or synthetic primary containment liner, as described in Section 13 of *Directive 055: Storage Requirements for the Upstream Petroleum Industry*, or a steel, plastic, or fibreglass reinforced vessel.

c) have curbs or berms (minimum height of 15 cm) to allow for the collection of any generated leachate; and

d) as a minimum, have the base 1 m above the saturated zone.

27) Licensees must manage any collected leachate, which includes precipitation that comes in contact with the waste mass, by one of the following methods:

a) irrigate over the drilling waste mass, provided that it does not hinder the biodegradation process or create a soil quality problem;

b) manage by following the pump-off management option set out in Section 11; or

c) inject down an approved disposal well.

28) Licensees may remove the curbs or berms of the containment system after one year, but one of the requirements below must be met:

a) The drilling waste contained within the system meets the following:

i. a 1:1 extract of a representative sample of the drilling waste with water passes a luminescent bacteria toxicity assessment; and

ii. an extract (obtained from the saturated paste filtrate method) of a representative sample of the drilling waste has EC and SAR values of no more than two and three units, respectively, above background soil values; or

b) The leachate collected from the containment system for three consecutive but independent sampling events that span 12 months has an extractable hydrocarbon (F2 to F4) content that does not exceed 15 mg/L and passes a luminescent bacteria toxicity assessment. A minimum sample size of 1 L must be collected for each event.

The need for curbs or berms must be re-evaluated if amendments or other materials are added to the treatment system or if tilling/turning identify nonbiodegraded hot spots.

29) Licensees must dismantle the containment system after the drilling waste is removed.

15.4.3 Management Options for the Biodegraded Drilling Waste Removed from the Containment System

30) After removing the biodegraded or partially biodegraded drilling waste from the containment system, licensees must manage it by one of the following methods:

a) land treatment, in accordance with the requirements in Section 15.3;

b) mix-bury-cover or landspreading, in accordance with the requirements in Sections 13 or 14;

c) treatment or disposal at an approved waste management facility, in accordance with the requirements in Section 17; or

d) as an ingredient to manufacture a product, provided the manufacturing company has confirmed in writing that the quality of the treated drilling waste material (physical and chemical) is suitable, and the ERCB has approved its use as an ingredient.

e) as a by-product, provided an application following the requirements of Section 19 has been made and ERCB approval has been obtained to use biodegraded or partially biodegraded drilling waste as a by-product. The application must include the by-product specifications and a scientific rationale that supports the specific use of the by-product. In addition,

i) for use of the by-product outside the boundaries of the well site or biodegradation site, the application must include information to confirm that the by-product material meets soil quality endpoints for coarse topsoil within the good soil rating category as set out in Section 3 and that the landowner or department/agency managing the land on behalf of the provincial or federal government has consented to the use, or

ii) for use of the by-product on the well site or biodegradation site, the application must describe the quality of the material as it relates to the soil quality objectives for the site and must include scientific information to support the specific use of the material

15.5 Information Requirements for Biodegradation Operations

31) Licensees must document information to verify that the drilling waste and site characterization requirements set out in Section 15.2 were met.

32) Licensees must also document the type of biodegradation operation (i.e., land treatment or biodegradation in a contained system) and the following information:

a) if biodegradation is being conducted on a site remote from the well site, a copy of the written agreement with the landowner or department/agency managing the land on behalf of the provincial or federal government and the well license to which the remote site in tied back or linked (refer to Section 15.2(4)(b);

b) the type of drilling mud system and fluid additives/mud products used;

c) the volume of drilling waste being managed, and the location, name, and licence number of the well(s) that generated the drilling waste;

d) the number, location, and depth of samples taken to characterize the biodegradation site, and the analytical results from the samples (i.e., background soil conditions);

e) if a contained system operation, containment system design and construction details supporting that

i) migration of contaminants beyond the containment system was prevented,

ii) any generated leachate was collected, and

iii) the entrance of surface waters into the containment system was prevented.

f) if a land treatment operation,

i) the information to support that the treatment zone and underlying soil were appropriate for the technique (i.e., per cent sand, fines, and clay; median grain size, LL, PI); and

ii) the dimensions of the area used for land treatment, and the drilling waste application method, rate, and depth of incorporation (i.e., the treatment zone).

g) a sketch of the site, including the biodegradation containment system or land treatment area and other key features, such as slope, topography, drainage features, surface water run-on control/leachate collection system, bodies of water, and water wells; and,

i) if on the well site, the location of the sump and well relative to the biodegradation area must also be identified on the sketch, or

ii) if off the well site, the biodegradation area must be mapped as a rectangle with the coordinates for the northeast and southwest corners being referenced from the northeast corner of the applicable section.

h) the commencement date of the biodegradation process and a photo of the area;

i) a description of the work done to manage, enhance, and monitor the biodegradation process, such as aerating the drilling waste mass or treatment zone, applying

amendments, and sampling and analyzing the drilling waste mass or treatment zone; and

i) the description must include the date the work was done, the method used to conduct the work, types and rates of amendments that were added, and the manner in which the waste mass or treatment zone was sampled and the results of the analysis.

j) the volume of any leachate collected, its characteristics, and how it was managed;

k) ERCB approvals if the biodegraded drilling waste removed from the containment system was used as a by-product; and

l) confirmation that the biodegradation site has been closed (i.e., soil conditions have been evaluated, the soil endpoints in Section 3 have been met, and the site has been reclaimed and restored to equivalent land capability) and the date closure was achieved.

33) Licensees must retain the documented information to make available to the ERCB upon request.

34) In addition to the notification requirements in Section 15.2 requirements (9), (10), and (11), licensees must also fulfill the pre- and post-disposal notification requirements set out in Sections 21.2 and 21.3.

16 Subsurface Disposal of Drilling Waste While Drilling

16.1 Introduction

Under appropriate conditions, subsurface disposal of drilling waste can be carried out without jeopardizing groundwater or impacting hydrocarbon-bearing zones. This method is a planned process that involves disposing drilling waste down the wellbore of a well that is in the process of being drilled and has had surface casing set and cemented to a depth that will cover the known base of groundwater protection. The zone being used for disposal of the drilling waste must be isolated from any hydrocarbon-bearing zones and groundwater.

16.2 Requirements

1) Licensees wishing to use this method must submit an application to the ERCB and obtain written approval before beginning disposal.

2) Licensees must provide the following information in the application:

   a) the type of drilling waste (e.g., freshwater gel chemical, salt water gel chemical, invert based) and volume to be managed by this method; confirmation that the drilling waste has a flashpoint that exceeds 61°C; the well licence number; and the surface hole and bottomhole location of the well that generated the drilling waste;

   b) the depth and geological formation to which the drilling waste will be disposed and the wellbore that will be used, including the well licence number, UWI, and surface location of the well;

   c) confirmation that there is a minimum of 150 m between the base of groundwater protection and the zone being used for disposal and that there is an impermeable formation separating the two zones;

   d) verification that the zone being used for disposal does **not** contain hydrocarbons within 1.6 linear kilometres (km) of the intended well being used for disposal;

   e) a plan that outlines the circumstances of the disposal, including a discussion as to whether the disposal is to occur in an open hole, behind cemented casing, or any other scenario;

   f) the estimated pressure needed to pump the drilling waste into the formation; and

   g) any other information as requested by the ERCB.

3) Licensees must submit the application through the Electronic Application Submission (EAS) process accessed through the Digital Data Submission (DDS) screen on the ERCB website at www.ercb.ca.

   Authorized ERCB customers require a login ID and password to access the DDS system. For help getting a login ID, please contact your company's ERCB DDS administrator. If you are unable to contact your company's ERCB DDS administrator, contact DDSAdministrator@ercb.ca.

   The ERCB will review all applications and those that are incomplete, contain errors, or do not meet the requirements for subsurface disposal will be closed.

17 Sending Drilling Waste to Approved Waste Management Facilities

17.1 Introduction

This section summarizes the requirements for the use of approved waste management facilities for drilling waste management. Waste management facilities include landfills, waste processing facilities, biodegradation facilities, thermal treatment facilities, and surface facilities associated with waste caverns and Class I disposal wells. Note that mobile thermal treatment units are not considered waste management facilities; refer to Section 18 for requirements regarding the use of mobile technology to thermally treat drilling waste.

Drilling waste generated in Alberta is a specific type of oilfield waste. When sending drilling waste to an approved waste management facility for treatment, processing, or disposal, licensees must adhere to all ERCB requirements pertaining to the management of oilfield wastes. This includes appropriate waste classification, characterization, and tracking.

In Alberta, waste management facilities are regulated by either the ERCB or AEW. AEW regulates most landfills in the province. Licensees must ensure that ERCB requirements are not contravened when using AEW-regulated waste management facilities.

As part of its compliance assurance process, the ERCB will conduct drilling waste audits to check for compliance with ERCB requirements. In the event of an audit, a licensee must submit relevant information to support that the use of a waste management facility for the drilling waste in question complied with ERCB requirements.

17.2 Requirements

This section summarizes oilfield waste management requirements applicable to drilling waste being sent to approved waste management facilities. The ERCB regulatory documents that set out the requirements are listed below, and any updates or changes to the requirements in these documents will supersede direction provided in this section:

- *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*
- *Interim Directive (ID) 2000-3: Harmonization of Waste Management*
- *Interim Directive (ID) 2000-4: An Update to the Requirements for the Appropriate Management of Oilfield Wastes*
- *Interim Directive (ID) 99-4: Deposition of Oilfield Wastes into Landfills*

1) Licensees must ensure the waste management facility is approved, and the facility approval must authorize the receipt of wastes exhibiting the properties of the drilling waste in question and the type of activity that will be used to manage the drilling waste. In addition, licensees must ensure use of the waste management facility does not contravene any of the restrictions or prohibitions listed in the following requirements.

   NOTE: Waste management facilities reducing the hydrocarbon content of oilfield wastes and drilling wastes by volatilization (passive or active) must be approved for the activity.

2) Licensees must

   a) retain information pertaining to the use of an approved waste management facility in the well file of the well that generated the waste;

   b) make the information available to the ERCB upon request; and

   c) use the information to support an application for reclamation certification of the well site or associated remote site, if applicable.

3) Licensees must ensure drilling waste being sent to an approved waste management facility in Alberta is classified as either a dangerous oilfield waste (DOW) or a non-dangerous oilfield waste (non-DOW) as specified in Part B of *Directive 058*.

   NOTE: The properties that typically cause drilling waste to be classified as DOW are flammability (flashpoint less than 61.5°C; note that the Transportation of Dangerous Goods Regulation [TDG] specifies a flashpoint of ≤ 60°C), leachate toxicity (leachable BTEX values exceed criteria in the Alberta User Guide for Waste Managers, published by AEW), and corrosivity (pH value less than 2 or greater than 12.5).

   The properties and criteria defining DOWs and hazardous wastes will be the same in ERCB and AEW requirements. Guidance documents developed by each agency and recommendations given to industry on the characterization and classification of specific wastes, the properties to be measured, the analytical methods to be used, and the chemical parameters to be tested will be consistent with the Alberta User Guide for Waste Managers.

4) For drilling waste that is classified as DOW, licensees must only send the waste to facilities approved to receive DOWs, hazardous wastes, or hazardous recyclables (drilling waste must be recycled if it is being sent to a recycling facility) as set out in *Directive 058*, *ID 2000-3*, and *ID 2000-4*.

5) If transporting drilling waste classified as DOW to a waste management facility in Alberta, licensees must ensure the waste is accompanied by a properly filled out Alberta Oilfield Waste Form as set out in Part C of *Directive 058* and *ID 2000-3*.

   NOTE: Shipments of wastes classified as DOW are subject to TDG.

   NOTE: Drilling wastes being exported out of Alberta are subject to the waste classification and manifest requirements under the *Environmental Protection and Enhancement Act* (EPEA) as identified in *ID 2000-3*.

6) For all drilling wastes sent to ERCB- or AEW-regulated waste management facilities, as well as those exported for treatment or disposal, licensees must ensure the wastes are tracked as reportable oilfield wastes as set out in Part C of *Directive 058* and *ID 2000-4*.

   NOTE: The waste codes for drilling waste (DRWSHC - hydrocarbon, DRWSGC - gel chemical, DRWSAC - advanced gel chemical) listed in ERCB Announcement 2009-03-26, Appendix 3 in *Direcitve 047: Waste Reporting Requirments for Oilfield Waste Management Facilities*, the Waste Management Table in Appendix 7 of *Directive 058* and any other subsequent updates, must be used to track the drilling wastes.

7) Licensees must ensure drilling waste is not mixed with any solids or liquids for the primary purpose of diluting it to avoid any Alberta regulatory requirement as set out in Section 5.5 of *Directive 058*.

8) Licensees sending drilling waste to landfills must comply with the following requirements:

   a) It is prohibited to deposit drilling waste into any registered landfill or any landfill currently operating under an Alberta Public Health permit that will qualify for registration under the *Code of Practice for Landfills*, pursuant to the *EPEA* as set out in *ID 2000-4*.

   b) Drilling waste sent to a landfill must pass the paint filter test (i.e., it must be a solid) and must be characterized and classified prior to the addition of adsorbents or bulking materials (e.g., sawdust, woodchips) as set out in *Directive 058* and *ID 99-4*.

      Provided that the drilling waste qualifies for acceptance into a landfill (passes paint filter test, does not exceed any waste acceptance criteria for the landfill, and waste classification is appropriate for the class of landfill), the subsequent addition of sorbent material required to facilitate its handling and to manage any interstitial liquids that could shake out during transportation to the landfill is acceptable.

   c) Drilling waste sent to an approved Class II landfill must be classified as a solid, non-DOW as set out in *Directive 058* and *ID 99-4*. If the landfill has design features alternative to a leachate collection and removal system and an engineered clay liner or synthetic liner, the concentrations of chloride (Cl) and total petroleum hydrocarbon (TPH) in the drilling waste must be correlated to the design of the landfill as set out in *ID 99-4* as summarized below.

Class II landfill design features[1]	Oilfield waste quality
Leachate collection/removal	TPH no limit
engineered clay[2] or synthetic liner	Cl no limit
No leachate collection/removal	TPH < 30 000 mg/kg
engineered clay or synthetic liner	Cl < 5000 mg/kg
No leachate collection	TPH < 20 000 mg/kg
Natural clay liner[3]	Cl < 3000 mg/kg

[1] All Class II landfills require surface water run-on/run-off control systems, suitable hydrogeology, and groundwater monitoring.

[2] Engineered clay liner: a liner constructed of appropriate clayey material where the material is laid down in 150- to 250-mm lifts, and each lift is compacted at 2 to 3 per cent wet of optimum moisture using a sheep's foot roller such that a thickness of 0.5 m or more and a hydraulic conductivity of 10^{-8} metres/second (m/s) or less is achieved.

[3] Natural clay liner: a liner constructed by scarifying and recompacting the native material (soil) in which the cell is built.

   d) Drilling waste sent to approved Class III landfills must be classified as a solid, non-DOW and must be inert as set out in *Directive 058* and *ID 99-4*.

      Inert waste is defined as any solid waste that upon disposal in a landfill is not reasonably expected to undergo physical, chemical, or biological changes to such an extent as to produce substances that may cause an adverse effect. Examples include demolition debris, concrete, asphalt, glass, cement returns, scrap metal, and dry timber or wood that has not been chemically treated. Drilling wastes will generally require extensive treatment before being rendered inert.

c) Drilling waste classified as DOW destined for landfill disposal must only be sent to a Class I landfill provided the drilling waste passes the paint filter test and does not exceed acceptance criteria for the landfill as set out in *Directive 058* and *ID 2000-4*.

9) Licensees must not send drilling waste to compost facilities or compost components at waste management facilities, including AEW-regulated landfills as set out in *ID 2000-4*.

10) Licensees must not send drilling waste to dedicated land treatment facilities (i.e., facilities approved by, or registered with, AEW for the treatment of soils contaminated with refined hydrocarbons) as set out in *ID 2000-4*.

18 Use of Mobile Thermal Treatment Units to Manage Drilling Waste

18.1 Introduction

Mobile thermal treatment units, which are regulated by AEW, may be used to thermally treat drilling waste provided that the units have received approval from or have been registered with AEW. Although thermal treatment can effectively reduce hydrocarbons and other organic compounds, it can also concentrate recalcitrant constituents, such as salts and metals. Upfront characterization of drilling waste is necessary to assess the options available for the final disposition of the thermally treated drilling waste (e.g., land application options or disposal at an approved waste management facility). The requirements in this section are based on those set out in Section 17.5 of *Directive 058*, and any updates to Section 17.5 will supersede the requirements of this section.

18.2 Thermally Treating Drilling Waste Requirements

1) Licensees must only conduct thermal treatment operations on a licensed well site or on a remote drilling waste storage or biodegradation site. Only drilling waste from the well where the unit is located can be treated. If the unit is on a remote drilling waste storage or biodegradation site, only the drilling waste generated by the well program being managed on the remote site can be treated.

2) Licensees must ensure the mobile treatment unit has an approval or registration from AEW, and all operations of the thermal treatment unit are in accordance with the approval or registration conditions. Drilling waste that exhibits properties that would classify it as a dangerous oilfield waste (DOW) must only be treated by thermal treatment units approved by AEW to treat hazardous waste.

3) In alignment with Section 5.5 of *Directive 058*, licensees must ensure drilling waste is not mixed with any solids or liquids for the primary purpose of diluting it to avoid any Alberta regulatory requirement (i.e., reduce constituent levels to change the drilling waste classification from a DOW to a non-DOW or to make it meet requirements specified for operation of the thermal unit).

4) Licensees must meet ERCB storage requirements (refer to *Directive 055: Storage Requirements for the Upstream Petroleum Industry*) while conducting thermal treatment operations, and the operation of the thermal treatment unit must not result in a contravention of any licence or approval condition for the well site or remote site.

5) Thirty days prior to beginning thermal treatment operations, licensees must electronically submit a notification to the ERCB containing the following:

   a) the location of the well site (surface) or remote drilling waste storage or biodegradation site on which the mobile thermal treatment unit will be located;

   b) the well licence number and UWI, if the mobile thermal treatment unit is located on the well site, or if located on a remote drilling waste storage or biodegradation site, the well licence and UWI to which the remote site is linked (see Sections 6.4[15] and 15.2[8]);

   c) the company/operator of the mobile unit and the AEW approval or registration number;

d) the volume and type of drilling waste (e.g., invert or hydrocarbon based, or previously treated waste) to be treated by the mobile unit;

e) the final disposition planned for the treated drilling waste (e.g., landspread or MBC following the requirements in *Directive 050*, or disposal at an approved waste management facility); and

f) the duration of the thermal treatment activity.

6) Licensees must electronically submit the notification to the ERCB in .pdf as an e-mail attachment in accordance with the following requirements:

a) E-mail the notification to Directive058@ercb.ca.

b) Ensure that the attachment file name identifies it as a drilling waste thermal treatment notification, contains the applicable well licence number and the UWI of the well that generated the drilling waste, and is formatted as DW_License#_UWI (e.g., ThermalTreatDW_0123456_00~12-14-025-12W4~0).

c) Ensure that the subject field of the e-mail contains the file name.

The ERCB will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliant event in accordance with *Directive 019*.

7) Thirty days before beginning thermal treatment operations, licensees must notify all landowners and residents within a 1.5-km radius of the site of the details of the intended activity. If the AEW approval or registration for the thermal treatment unit identifies conditions for public notification, then the most stringent public notification requirements must be met.

8) Licensees must notify the local ERCB field centre of the details of the intended activity at least 48 hours before beginning thermal treatment operations.

9) Licensees must track the volume and type of drilling waste thermally treated, as well as the final disposition of the treated drilling waste, and include the information in the post-disposal notification as required by Section 21.4.

19 Alternative Management Methods

19.1 Introduction

While the ERCB does not certify or approve specific technologies, mud products, or mud systems, licensees must obtain ERCB approval to manage drilling waste in a manner alternative to the requirements set out in this directive.

This section outlines the minimum information that must be electronically submitted in an application to the ERCB to

- manage drilling waste using a technology or treatment method not set out in this directive;
- land-apply drilling waste generated by a new or unique mud system using an option set out in this directive (e.g., mix-bury-cover, landspread, landspray, pump-off); or
- modify a method set out in this directive (e.g., exceed nitrogen application rate for a disposal method).

19.2 Alternative Management Methods Requirements

1) Licensees must provide sufficient information in the application to substantiate that the proposed systems, procedures, or technologies will achieve a level of environmental protection and safety equivalent to the methods set out in this directive. Details regarding the need for an alternative method, including supporting science and technical rationale, must be included in the application. If applicable, the ERCB will work with other government agencies (e.g., SRD, AEW, Department of National Defence, Indian Oil and Gas Canada) to ensure any concerns are addressed in the developmental stages.

2) Licensees must obtain ERCB approval prior to implementing the alternative management method.

19.3 Application Information Requirements

The level of detail submitted in the application should reflect the scope and complexity of the proposed alternative management method.

3) Licensees must submit an application containing, as a minimum, the following information:

   a) date of application;

   b) name, address, and phone number of the well licensee;

   c) legal land location (surface), well licence number, and UWI of the well that generated the drilling waste;

   d) the legal land location of the site or area on which the alternative method is being conducted and if it is a remote drilling waste storage or biodegradation site, the well licence number and UWI to which the remote site is tied back or linked (refer to Sections 6.4 and 15.2[4][b]);

e) current land use (e.g., agricultural, natural area, or parkland) of the site and adjacent lands and whether the site is on private land, public land, or any other land type identified in Section 1.6;

f) proposed start date and date of completion;

g) a general description of the proposed alternative method, including the overall purpose or goal of the method, an assessment of its need, and any literature or bench-scale work to substantiate the method's potential for success;

h) site assessment information, including

   i) a plot plan at an appropriate scale that identifies site topography, surface drainage patterns, types of vegetation or tree cover, and the location of the proposed alternative method relative to other areas of activity or infrastructure on the site (e.g., gas/oil well, drilling sump, biodegradation area, on-site water well, storage tanks or other storage systems, pipelines or utility lines); and

   ii) applicable background soil conditions as described in Section 3, should the alternative method involve application of the drilling waste to land.

i) a description of the process design and operational requirements of the alternative method, including

   i) the type (e.g., chemical and physical characteristics, new mud additive, new mud system) and volume of drilling waste to be managed by the alternative method;

   ii) any amendments or chemicals that will be added and their purpose;

   iii) methods of storing and containing the drilling waste before, during, and after employment of the alternative method;

   iv) if applicable, a schematic of the process design/operation and a process flow diagram;

   v) any related technical or research papers, or bench-scale or pilot projects, that would scientifically support the potential for the method to succeed;

   vi) final disposition of the drilling waste or by-products resulting from the method with information/rationale to support the applicability of the final disposition (should land application be involved, information must include the fate of the drilling waste or any resulting by-products in the soil environment with supporting chemical reactions and bioassay/toxicity assessment information);

   vii) management method for any leachate generated by the method;

   viii) limitations of the alternative method with respect to drilling waste characteristics (physical, chemical, or toxicological), site restrictions, or operational matters; and

   ix) any potential fugitive emissions and plans to mitigate and monitor potential impacts resulting from the emissions.

j) a description of the process that will be used to measure the success of the alternative method; the process may include

   i) testing for analytes of interest,

   ii) developing a sampling protocol,

   iii) conducting analyses to monitor progress, or

   iv) undertaking a detailed characterization of the drilling waste and, if applicable, the receiving soil or resulting by-products before and after the management method.

4) Licensees must electronically submit the application through the Electronic Application Submission (EAS) process accessed through the Digital Data Submission (DDS) screen on the ERCB website at www.ercb.ca.

   Authorized ERCB customers require a login ID and password to access the DDS system. For help getting a login ID please contact your company's ERCB DDS administrator. If you are unable to contact your company's ERCB DDS administrator, contact DDSAdministrator@ercb.ca.

   The ERCB will review all applications and those that are incomplete, contain errors, or do not meet applicable criteria specific to the alternative method will be closed.

20 Remixing a Former Drilling Waste Disposal

20.1 Introduction

Prior to 1993, drilling waste management direction was limited, and common practices included backfilling sumps and burying drilling waste. *Guide 50*, now *Directive 050*, was first issued in 1993 and then was updated in 1996. Remediation and reclamation guidelines have advanced significantly since 1996, which can present challenges when trying to obtain regulatory closure (i.e., reclamation certification) for well sites and associated sites used to manage drilling wastes. In some cases, licensees have conducted phase 2 environmental site assessments and determined that exhuming the drilling waste disposal area and remixing it with subsoil would resolve the remediation and reclamation challenges.

While remixing has advantages over excavating and hauling the drilling waste to a waste management facility (often referred to as dig and dump, which also requires the excavation to be filled with suitable subsoils), it can significantly disturb the site. This option is limited to drilling waste disposals where current landspread or MBC soil endpoints (refer to Tables 3.1, 3.2, and 3.4) can be met using a mix ratio of no more than three parts subsoil to one part drilling waste. The size of the disturbance caused by the remix activity must also be evaluated when considering this option.

This section sets out the requirements to remix an old drilling waste disposal, as well as a notification process for the activity.

20.2 Requirements to Remix a Former Drilling Waste Disposal

1) Licensees must meet the following requirements when remixing old drilling waste disposals

   a) The remix must only be conducted on a licensed well site or associated remote drilling waste storage site on which an original drilling waste disposal occurred.

   b) The old drilling waste disposal area must be vertically and horizontally delineated.

   c) Representative samples must be been taken and lab-analyzed to determine background soil conditions and the quality of the drilling waste disposal area; samples must be analyzed for hydrocarbons (BTEX components and F1-F4 hydrocarbon fractions), metals, major ions, EC, and SAR.

   d) Predictive lab mixes must be done to determine the soil/waste mix ratio that will meet the soil endpoints for salts, hydrocarbons, and metals for landspread or MBC as set out in Tables 3.1, 3.2 and 3.4 (refer to Section A2.4 of Appendix 2 for information about lab predictive mixes).

   e) The mix ratio for the remix must not exceed 3 parts subsoil to 1 part drilling waste.

   f) The remix must be done at the soil horizon depth that correlates to the salinities set out in Table 3.1 for the landspread or MBC option being used.

   g) The volume of the drilling waste and soil to be re-mixed must be determined and used to gauge the size of disturbance needed for a successful remix.

   h) The pros and cons of the site disturbance required for the remix option must be compared with those of the dig and dump option.

i) If the site is on public pands, SRD must agree with the remix option.

20.3 Notification Requirements

2) Licensees must electronically submit a notification to the ERCB at least 30 days before beginning remix activity. The notification must, as a minimum, contain the following information:

   a) date of notification;

   b) name, address, and phone number of the licensee;

   c) legal land location (surface) of the site on which the remix is to take place and the licence number and UWI of the well that generated the drilling waste or of the well to which the site is linked (refer to Section 6.4[15]);

   d) a description of the proposed remix with supporting documentation to substantiate the appropriateness and applicability of the remix, which must include:

      i) the history of the site, including the year of the original drilling waste disposal;

      ii) a plot plan identifying the area of the original drilling waste disposal, the area encompassing the proposed remix, the location and depths of the boreholes/samples taken to delineate and assess the conditions of the original drilling waste disposal and background soils, and the topographical features of the site and any existing infrastructure;

      iii) soil borehole logs from the site assessment, summary of the analytical results and lab predictive mixes to substantiate that the remix will achieve the endpoints set out in Tables 3.1, 3.3, and 3.4;

      iv) the soil horizon depth at which the remix is to occur, the soil-to-waste mix ratio used for the remix, and the remix disposal method (i.e., landspread with good category subsoils, landspread with fair category subsoils, MBC between 1 and 1.5 m deep with good or fair category subsoils, or MBC at 1.5 m or deeper with no subsoil category restriction); and

      v) if the site is on Public Lands, correspondence to confirm that SRD is in agreement with the remix.

3) Licensees must electronically submit the notification to the ERCB in .pdf as an e-mail attachment as follows:

   a) E-mail the notification to Directive050@ercb.ca.

   b) Ensure that the attachment file name identifies it as a drilling waste remix notification, contains the applicable well licence number and the UWI of the well that generated the drilling waste or to which it is linked, and is formatted as DW_License#_UWI (e.g., RemixDW_0123456_00~12-14-025-12W4~0).

   c) Ensure that the subject field of the e-mail contains the file name.

The ERCB will return notifications that do not address all of the required information to the licensee and will consider commencement of any activity associated with the notification as a noncompliant event in accordance with Directive 019.

4) Licensees must notify the local ERCB field centre and give them the details of the intended remix at least 48 hours before beginning it.

21 Record Keeping and Notification

21.1 Introduction

The record keeping and notification requirements in this section pertain to drilling wastes from wells. Record keeping and notification requirements for drilling wastes from pipelines are set out in Section 8 of this directive.

21.2 Record Keeping Requirements

The ERCB requires licensees to maintain records to demonstrate compliance.

1) Licensees must document the following information and retain it in the well file of the well that generated the drilling waste and make the information available to the ERCB upon request:

   a) The surface land location, UWI, and well licence number of the well that generated the drilling waste.

   b) The type of drilling mud system used, including

      i) a list of all fluid additives and mud products used;

      ii) the volume of each fluid additive and mud product added;

      iii) luminescent bacteria toxicity documentation, if available, for all fluid additives and mud products used; and

      iv) metal content documentation, if available, for all of all of the fluid additives and mud products used and the cumulative metal content of the mud system.

      If different mud systems were used for different sections of the hole and were segregated and managed separately, the above information must be documented for each system.

   c) The method used to store the drilling waste, including information to demonstrate compliance with Section 6 of *Directive 050* and a plot plan identifying the location of the storage system, and the following, as applicable:

      i) If a remote site was used to store drilling waste, in addition to the above, the legal land location of the remote site and a copy of the written agreement for use of the site from the landowner or Crown department/agency managing the land (refer to Section 1.6).

      ii) If more than one well contributed drilling waste to the storage system, the well licence of the well that first contributed drilling waste (i.e., well licence to which the remote site is linked as set out in Section 6.4[15]).

   d) The volume of drilling waste generated and the management method used, including

      i) drilling waste assessment information, including analytical and field testing results, as well as a sketch of the sump or drilling waste storage system showing the locations and depths of the subsamples taken to obtain the representative composite drilling waste sample;

ii) the name, location, and approval number of any waste management facility to which drilling waste was sent;

iii) the following information for any land application/disposal method used (Sections 9 to 14)

- receiving soil assessment information;
- if applicable, post-disposal sampling information;
- a detailed map of the disposal area;
- proof of landowner/department/agency consent; and
- the drilling waste disposal rates and supporting calculations.

e) If different drilling waste types (as a result of different mud systems being used) or phases (e.g., clear liquids, fluids, solids, cuttings, total waste, cement returns, drillstem test fluids) were segregated, the information in points (b), (c) and (d) above must be documented for the management of each segregated type or phase.

f) If biodegradation was used to manage the drilling waste, the information requirements in Section 15.5 must also be documented.

2) Licensees must retain the information from requirement 1 above in the well file until the well site and any associated remote drilling waste storage or biodegradation site have successfully been reclaimed (this involves getting, for specified lands, a reclamation certificate from AEW or SRD; for non-specified lands, documentation from the department/agency managing the land on behalf of the Crown identifying that reclamation requirements have been met).

21.3 Pre-disposal Notification Requirements

3) Licensees must electronically submit drilling waste disposal notification information in conjunction with the drilling activity notification through the ERCB Digital Data Submission (DDS) systems, Field Surveillance Inspection System (FIS) Drilling Activity Notification form.

4) Licensees must enter the following information about the proposed drilling waste disposal activities on the Drilling Activity Notification Form:

a) drilling fluid/mud type(s);

b) proposed drilling waste disposal method(s) and location(s);

c) location of remote sump or biodegradation site, if one is to be used; and

d) environmental contractor information.

Changes to the drilling activity notification record are allowed on the DDS system up to 48 hours from the Drilling Activity Start Date. Licensees should consider the drilling waste disposal before this time passes and update the Drilling Activity Notification with appropriate information. Any changes to the disposal plan after 48 hours from the Drilling Activity Start Date must be clearly documented and retained in the well file.

Changes to the Drilling Activity Start Date can also be made provided the new date is within 48 hours of the original date. For a change that exceeds 48 hours, licensees are to contact the appropriate ERCB field centre and provide the new date and any corresponding changes to the drilling waste disposal plan, if required.

Authorized ERCB customers require a login ID and password to access the DDS system. For help getting a login ID, please contact your company's ERCB DDS administrator. If you are unable to contact your company's ERCB DDS administrator, contact DDSAdministrator@ercb.ca.

Detailed instructions for submitting information about drilling activities (including drilling waste information) is in the FIS website User Guide. Inquiries may also be directed to the FIS administrator by telephone at (403) 297-4845 or by e-mail at FIS.Administrator@ercb.ca.

21.4 Post-disposal Notification Requirements

5) Licensees must also electronically submit post-disposal information identifying the drilling waste volumes actually generated, the management or disposal options used, and the disposal locations. A *Directive 050: Drilling Waste Management Disposal Form* must be filled out for each well licence and submitted within 24 months of rig release of the well that first contributed drilling waste to the storage system (e.g., within six months of the date required for removal of drilling waste from the storage system; refer to Section 6 for details on drilling waste storage duration).

6) Licensees must submit the disposal information through the Digital Data Submission (DDS) screen on the ERCB website at www.ercb.ca. The disposal form is located under ERCB/Submissions/DrillingWasteData/SubmitWasteData; select Well Disposal as the Submisison Type. Licensees must also retain a copy of the completed form in the well file.

   Authorized ERCB customers require a login ID and password to access the DDS system. For help getting a login ID please contact your company's ERCB DDS administrator. If you are unable to contact your company's ERCB DDS administrator, contact DDSAdministrator@ercb.ca.

Appendix 1 *Directive 050* Background

The ERCB first provided direction on drilling waste management in 1975 with the publication of *Interim Directive No. ID-OG 75-2: Sump Fluid Disposal Requirements*. Changes in drilling mud technology and an increased awareness of the need to protect the environment resulted in a review of drilling waste characteristics and the development of the 1993 edition of *Guide 50: Drilling Waste Management* (now known as *Directive 050*).

A review of data from about 4200 wells resulted in the 1995 publication of the *Interim Working Document for Drilling Waste Management*, which was introduced with *General Bulletin 95-04: Drilling Waste Management*. The interim working document provided updates on sampling and analytical requirements, data requirements, and criteria for drilling waste disposals.

Additional review of the interim working document resulted in the publication of the 1996 edition of *Directive 050*. The disposal methods set out in the 1996 edition specified maximum loading rate (in kilograms per hectare) or total load (in kilograms) of a parameter in the drilling waste that could be applied to land. It also required that a notification of drilling waste disposal be submitted to the appropriate regulatory agency at certain stages of the disposal and that a copy of the notification be submitted to the drilling waste database, which was maintained by CGI Information Systems and Management Consultants Inc. for the Canadian Association of Petroleum Producers (CAPP). CAPP stopped funding this database in 2004.

In 2006, the ERCB issued *Directive 045: Digital Data Submission of Drilling Waste Disposal Notification*, which changed the notification requirements and clarified that the ERCB is the regulatory agency responsible for drilling waste management in Alberta.

The early 1990s saw the publication of numerical criteria for soils, which served as benchmarks against which to assess the degree of contamination at a site, the need for remediation, and the acceptable concentration of soil contaminants. Examples include the Canadian Council of Ministers of the Environment (CCME) *Interim Canadian Quality Criteria for Contaminated Sites* (1991) and Alberta Environment *Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation* (1994).

Through the late 1990s, national environmental quality assessment and management guidelines were developed using a conservative, generic form of risk assessment designed to preserve a range of developments, activities, and conditions with distinct land use categories or sensitivities (CCME 1996a, b, 1997, and 1999). AEW also applied the concept of risk assessment for the derivation of soil and remediation objects set out in

- *Alberta Soil and Water Quality Guidelines for Hydrocarbons at Upstream Petroleum Oil and Gas Sites* (2001);
- *Soil Remediation Guidelines for Barite: Environmental Health and Human Health* (2004 and updated 2009); and
- *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2007 and updated 2008, 2009, 2010, and 2012).

Also through the late 1990s and early 2000s, the ERCB worked with AEW and SRD to ensure that there was a harmonized approach to waste management and to clarify regulatory roles and responsibilities in this area. The need to harmonize drilling waste management

requirements with other waste management requirements, combined with the advancement of environmental quality guidelines and the development of the 2003 Upstream Oil and Gas Reclamation and Remediation Program, resulted in a government/industry multi-stakeholder review of the 1996 edition of *Directive 050*. The ERCB chaired the review. The information generated through the review and in current regulatory documents was used to develop a draft revision to *Directive 050*, which was released for public review on September 10, 2007.

The comments received were assessed against current soil, environmental, and analytical sciences, as well as against regulatory requirements and procedures. To assist with this assessment, the ERCB held meetings and corresponded with representatives of industry and environmental associations and of federal and provincial government agencies. The 2007 draft edition of *Directive 050* was revised and released for a second round of public review on April 18, 2011.

The ERCB considered the comments received through the public review, in consultation with AEW and SRD, in finalizing the 2012 edition of *Directive 050*.

The ERCB recommends that further investigation be done to determine the feasibility of using terrestrial toxicity tests to set toxicity threshold levels for drilling fluid additives and mud products and to identify environmentally toxic drilling wastes.

Appendix 2 Salinity and Nitrogen

A2.1 Introduction

To preserve good-quality soils, drilling waste must be managed to comply with the following in the soil-waste mix:

- a maximum allowable increase in electrical conductivity (EC) and sodium adsorption ratio (SAR); and
- an upper limit on post-disposal EC and SAR.

The allowable increases and upper limits are set out in Table 3.1 and depend on the receiving soil rating category and depth, as well as the drilling waste disposal method.

Waste application limits based on calculations involving EC, SAR, and sodium concentration are the most comprehensive analytical parameters to use to establish a waste's salinity. From these values, calculated spread rates or predictive mixes can be carried out to determine safe addition levels. The purpose of this appendix is to provide salinity calculations for each drilling waste disposal method. A recommended lab mixing protocol is also provided at the end of this appendix.

It must be emphasized that site-specific conditions, such as particular environments and climatic conditions, may result in the specified EC and SAR limits being too high for environmental protection.

A2.2 Salinity Calculations

A2.2.1 Mix-Bury-Cover

The following simplified calculations may be used for wastes with an EC less than 10 dS/m as an alternative to predictive lab mixes.

Electrical Conductivity

The following calculations should be used to determine mix ratio as a function of waste EC.

Equation (1) for oversaturated wastes:

$$\text{Mix ratio} = \frac{\text{Waste EC} \times \Phi}{\text{EC target increase}} - 1 \qquad (1)$$

Mix ratio = Ratio of soil to waste

Waste EC = Electrical conductivity (dS/m) of saturated paste extract

Φ = Volume fraction of water in waste $= \dfrac{2.65 - \text{SGfm}}{1.65}$

SGfm = Specific gravity of the field-moist waste, measured using an American Petroleum Institute (API) mud balance

EC target increase = Maximum EC increase from Table 3.1 (dS/m)

Equation (2) for undersaturated wastes:

$$\text{Mix ratio} = \frac{\text{Waste EC} \times \text{SLR}}{\text{EC target increase} \times (1 - \Phi)} - 1 \qquad (2)$$

Mix ratio = Ratio of soil to waste

Waste EC = Electrical conductivity (dS/m) of saturated paste extract

EC target increase = Maximum EC increase from Table 3.1 (dS/m)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(\text{SGsp} - 1)}{(2.65 - \text{SGsp})}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{SGfm}}{1.65}$$

A2.2.2 Landspreading and Land Treatment

Electrical Conductivity

Mix ratios must first be calculated using equation (1) or (2). The waste application rate is then calculated using equation (3):

$$\text{Application rate} = \frac{\text{Tillage depth} \times 100}{\text{Mix ratio} + 1} \qquad (3)$$

Application rate = Waste application rate (m^3/ha)

Tillage depth = Depth (cm) of tillage from top of waste layer

Mix ratio = Ratio of soil to waste (v/v)

Soil Correction Factor for Electrical Conductivity

Equations (1) and (2) target a given increase in soil EC regardless of background soil EC. When landspreading or land treatment occurs above the 1-m depth, the post-disposal EC must not exceed the maximum EC in Table 3.1. In order to ensure that the maximum EC is not exceeded, a correction factor must be applied for soils with a background EC greater than 1 dS/m. The waste application rate must be multiplied by the soil correction factor for all soils with a background EC greater than 1.

The soil correction factor for subsoil is calculated using equation (4), and the correction factor for topsoil is calculated using equation (5):

$$\text{Soil Correction Factor (subsoil)} = \frac{3 - \text{Background soil EC}}{2} \qquad (4)$$

Soil Correction Factor (topsoil) = 2 - Background soil EC (5)

Background soil EC = Electrical conductivity of soil before waste application (dS/m)

Equations (4) and (5) must not be used when background soil EC is less than 1 dS/m.

Sodium

The sodium application rate must not exceed 500 kg/ha. The sodium-based loading rate should be calculated using the following equations:

Equation (6) for oversaturated wastes:

$$\text{Waste application rate} = \frac{500\,000}{\text{Waste Na concentration} \times \Phi} \qquad (6)$$

Waste application rate = Waste application rate (m^3/ha)

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{1.65}$

SGfm = Specific gravity of the field-moist waste measured using an API mud balance

Equation (7) for undersaturated wastes:

$$\text{Application rate} = \frac{SLR \times 500\,000}{\text{Waste Na concentration} \times (1 - \Phi)} \qquad (7)$$

Application rate = Waste application rate (m^3/ha)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(SGsp - 1)}{(2.65 - SGsp)}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{1.65}$

A2.2.3 Landspray

The application rate for drilling waste should be based on EC and sodium loading rates. Specific requirements also apply to nitrogen content.

Soil Correction Factor for Electrical Conductivity

The following equations allow a 1 dS/m increase in soil EC. To ensure that the EC limit of 2 dS/m is not exceeded, a correction factor must be applied for soils with a background EC greater than 1 dS/m. The soil correction factor is calculated using equation (5). The waste application rate must be multiplied by the soil correction factor for all soils with a background EC greater than 1 dS/m.

Soil correction factor = 2 - Background soil EC (5)

Background soil EC = Electrical conductivity of soil before waste application (dS/m)

Equation (5) must not be used when background soil EC is less than 1 dS/m.

Landspray with Soil Incorporation—Electrical Conductivity

The following calculations should be used to determine application rate as a function of waste EC for soil with a background EC of 1 dS/m or less.

Equation (8) for oversaturated wastes:

$$\text{Application rate} = \frac{\text{Tillage depth} \times 54}{\text{Waste EC} \times \Phi} \qquad (8)$$

Application rate = Waste application rate (m^3/ha)

Tillage depth = Depth of tillage (cm), maximum 10 cm

Waste EC = Electrical conductivity (dS/m) of waste slurry

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{SGfm}}{1.65}$$

SGfm = Specific gravity of the waste, measured using an API mud balance

Equation (9) for undersaturated wastes:

$$\text{Application rate} = \frac{\text{Tillage depth} \times \text{SLR} \times 54}{\text{Waste EC} \times (1 - \Phi)} \qquad (9)$$

Application rate = Waste application rate (m^3/ha)

Tillage depth = Depth of tillage (cm), maximum of 10 cm

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(\text{SGsp} - 1)}{(2.65 - \text{SGsp})}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Waste EC = Electrical conductivity (dS/m) of saturated paste extract

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{SGfm}}{1.65}$$

The maximum value that should be used in equations (8) and (9) for tillage depth is 10 cm, because 10 cm is a reasonably average depth of incorporation. Waste applied to cultivated land should be incorporated to the mixing depth before the crop is seeded.

Landspray with Soil Incorporation—Sodium

The sodium application rate must not exceed 250 kg/ha. Sodium-based loading rate should be calculated using the following equations.

Equation (10) for oversaturated wastes:

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration} \times \Phi} \qquad (10)$$

Waste application rate = Waste application rate (m^3/ha)

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{Waste Specific Gravity}}{1.65}$$

SGfm = Specific gravity of the field-moist waste measured using an API mud balance

Equation (11) for undersaturated wastes:

$$\text{Application rate} = \frac{\text{SLR} \times 250\,000}{\text{Waste Na concentration} \times (1 - \Phi)} \qquad (11)$$

Application rate = Waste application rate (m^3/ha)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(\text{SGsp} - 1)}{(2.65 - \text{SGsp})}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{SGfm}}{1.65}$$

Landspray with No Soil Incorporation—Electrical Conductivity

The following calculations should be used to determine application rate as a function of waste EC.

Equation (12) for oversaturated wastes:

$$\text{Application rate} = \frac{160}{\text{Waste EC} \times \Phi} \qquad (12)$$

Application rate = Waste application rate (m^3/ha)

Waste EC = Electrical conductivity (dS/m) of waste slurry

Φ = Volume fraction of water in waste = $\frac{2.65 - \text{SGfm}}{1.65}$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

Equation (13) for undersaturated wastes:

$$\text{Application rate} = \frac{\text{SLR} \times 160}{\text{Waste EC} \times (1 - \Phi)} \qquad (13)$$

Application rate = Waste application rate (m^3/ha)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(\text{SGsp} - 1)}{(2.65 - \text{SGsp})}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Waste EC = Electrical conductivity (dS/m) of saturated paste extract

Φ = Volume fraction of water in waste = $\frac{2.65 - \text{SGfm}}{1.65}$

A minimum application rate of 10 m^3/ha is recommended for calculating salinity loading rates.

Landspray with No Soil Incorporation—Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using either equation (10) or (11).

Equation (10) for oversaturated wastes:

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration} \times \Phi} \qquad (10)$$

Waste application rate = Waste application rate (m^3/ha)

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{SGfm}}{1.65}$$

SGfm = Specific gravity of the field-moist waste measured using an API mud balance

Equation (11) for undersaturated wastes:

$$\text{Application rate} = \frac{\text{SLR} \times 250\,000}{\text{Waste Na Concentration} \times (1 - \Phi)} \qquad (11)$$

Application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(\text{SGsp} - 1)}{(2.65 - \text{SGsp})}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{SGfm}}{1.65}$$

Additional Restrictions

Waste application rates based on salinity or sodium should not override the solids loading limit of 6 t/ha if the waste is not being incorporated into the soil.

The pH of waste applied to vegetated land must not be less than 6.0 or more than 10.5.

Caution should be exercised when applying saline wastes to hay and pasture land where salt-sensitive species are growing. Salt-sensitive species include, but are not limited to, red clover, alsike clover, alfalfa, and timothy. The potential for damage to vegetation is especially high when the soil is dry. Extreme caution should be used when conducting landspray disposals on no-till fields in the spring before seeding.

A2.2.4 Landspray While Drilling

A maximum EC of 16 dS/m is recommended for all landspray-while-drilling (LWD) operations, except nitrogen systems (refer to Section A2.3). Although disposal with soil incorporation is at the discretion of the landowner, the LWD method is designed to ensure that the drilling waste/soil mix meets all applicable endpoints without incorporation.

Soil Correction Factor for Electrical Conductivity

The following equations allow a 1 dS/m increase in soil EC. To ensure that the EC limit of 2 dS/m is not exceeded, a correction factor must be applied for soils with a background EC greater than 1 dS/m. The soil correction factor is calculated using equation (5). The waste application rate must be multiplied by the soil correction factor for all soils with a background EC greater than 1.

$$\text{Soil correction factor} = 2 - \text{Background soil EC} \qquad (5)$$

Background Soil EC = Electrical conductivity of soil before waste application (dS/m)

Equation (5) must not be used when background soil EC is less than 1 dS/m.

Electrical Conductivity

Equation (12) should be used to determine application rate as a function of waste EC.

$$\text{Application rate} = \frac{160}{\text{Waste EC} \times \Phi} \qquad (12)$$

Application rate = Waste application rate in m^3/ha

Waste EC = Electrical conductivity of waste slurry in dS/m

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{1.65}$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

A minimum application rate of 10 m^3/ha is recommended for the purposes of calculating salinities load rates.

Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using equation (10).

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration} \times \Phi} \qquad (10)$$

Waste application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - SGfm}{1.65}$$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

Other Restrictions

Waste application rates based on salinity or sodium must not exceed the solids loading limit of 6 t/ha.

The pH of waste applied to vegetated land should not be less than 6.0 or more than 10.5.

Caution should be exercised when applying saline wastes to hay and pasture land where salt sensitive species are growing. Salt-sensitive species include, but are not limited to, red clover, alsike clover, alfalfa, and timothy. The potential for damage to vegetation is especially high when the soil is dry. Extreme caution should be used when conducting LWD disposals on no-till fields in the spring prior to seeding.

A2.2.5 Landspraying on Forested Public Lands

Electrical Conductivity

Waste EC should not exceed 10 dS/m. The waste application rate must not exceed 80 m^3/ha.

Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using either equation (10) or (11).

Equation (10) for oversaturated wastes:

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration} \times \Phi} \qquad (10)$$

Waste application rate = Waste application rate (m^3/ha)

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{Waste specific gravity}}{1.65}$$

SGfm = Specific gravity of the field-moist waste measured using an API mud balance

Equation (11) for undersaturated wastes:

$$\text{Application rate} = \frac{SLR \times 250\,000}{\text{Waste Na concentration} \times (1 - \Phi)} \qquad (11)$$

Application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(SGsp - 1)}{(2.65 - SGsp)}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Φ =Volume fraction of water in waste = $\frac{2.65\text{-}SGfm}{1.65}$

A2.2.6 Pump-off

Soil Correction Factor

The following equation allows a 1 dS/m increase in soil EC. In order to ensure that the EC limit of 2 dS/m is not exceeded, a correction factor must be applied for soils with a background EC greater than 1 dS/m. The soil correction factor is calculated using equation (5). The waste application rate must be multiplied by the soil correction factor for all soils with a background EC greater than 1.

Soil correction factor = 2 - Background soil EC (5)

Background soil EC = Electrical conductivity of soil before waste application (dS/m)

Equation (5) must not be used when background soil EC is less than 1 dS/m.

Electrical Conductivity

Waste EC should not exceed 10 dS/m.

The application rate for waste that does not contain nitrogen should be based on EC and sodium loading rate. The following calculation should be used to determine application rate as a function of waste EC:

$$\text{Application rate} = \frac{1600}{\text{Waste EC}} \qquad (14)$$

Application rate = Waste application rate in m^3/ha

Waste EC = Electrical conductivity of waste slurry (dS/m), maximum 10 dS/m

Sodium

The sodium application rate must not exceed 250 kg/ha. The sodium-based loading rate should be calculated using equation (10).

$$\text{Waste application rate} = \frac{250\,000}{\text{Waste Na concentration}} \qquad (10)$$

Waste application rate = Waste application rate in m^3/ha

Waste Na concentration = Sodium concentration in waste filtrate (mg/L)

Other Restrictions

The pH of waste applied to vegetated land should not be less than 6.0 or more than 8.5.

Caution should be exercised when applying saline wastes where salt-sensitive species are growing. Salt-sensitive species include, but are not limited to, red clover, alsike clover, alfalfa, timothy, and many forest species. The potential for damage to vegetation is especially high when the soil is dry. Caution must be exercised under dry conditions, and it may be necessary to use other disposal options.

A2.3 Recommended Nitrogen Loading Rate Objectives

In some cases, landowners may wish to apply nitrogen-containing drilling wastes to land to increase the amount of nitrogen in the soil. Depending on the composition of the drilling wastes, either salinity or nitrogen may be the limiting parameter when wastes are surface applied. The importance of EC and SAR in determining salinity must be balanced against nitrogen loading criteria. Calculations for determining whether the waste application rate must be based on salinity or nitrogen are provided under each surface disposal option. **Licensees wishing to apply drilling wastes to land using nitrogen loading rates must apply to the ERCB for approval before beginning the disposal.** The application must contain sufficient information to support the nitrogen loading rates.

A2.3.1 Determining When Nitrogen Application Rates May be Used for Landspray, Landspray While Drilling, Pump-off, and Disposal onto Forested Public Lands

Application rates based on product addition that result in < 25 kg N/ha do not require specific nitrogen analysis and should be disposed of according to EC and SAR requirements. The nitrogen application rate may be estimated as follows:

$$\text{N application rate} = \frac{\text{Units of product used x mass/product unit x N in product}}{\text{Disposal area x 100}} \qquad (15)$$

N application rate = Amount of N applied in waste (kg/ha)

Units of product = Number of product containers used (sack/pail/drum)

Mass/product unit = Mass of product in container (kg/container)

N in product = Concentration of N in product (%)

Disposal area = Area to which waste is applied (ha)

All sources of nitrogen must be considered, and recycled wastes must include all product additions (e.g., all mud addition on previous and current wells).

Assessing Salinity in Nitrogen-based Wastes

If the nitrogen application rate, according to equation (15), is equal to or greater than 25 kg/ha, the nitrogen loading limits in Table A2.2 or site-specific application rates must be used. Because nitrogen and non-nitrogen salts both contribute to salinity, the following equation must be used to determine whether non-nitrogen salinity constraints override nitrogen-based application rates. If the EC to nitrogen ratio measured in the waste is greater than the critical ratio calculated by equation (16), waste application rates must be based on EC (or sodium, whichever is lower) loading limits, as specified above.

$$\text{Critical EC: N Ratio} = \frac{\text{Mixing depth x } 0.027}{\text{N application rate}} + \text{Conductivity factor} \quad (16)$$

Critical EC:N ratio = Ratio of waste EC (dS/m) to waste N concentration (mg/L)

Mixing depth = Depth (cm) of tillage or infiltration

If wastes are incorporated into the soil, use the tillage depth to a maximum of 10 cm.

If wastes are not incorporated into the soil, use 30 cm for pump-off and 3 cm for LWD, disposal onto forested Public Lands, and landspray.

Waste N concentration = Sum of all mineral N species (NH_4-N, NO_3-N, NO_2-N) (mg/L)

N application rate = Amount of N applied in waste (kg/ha) from Table A2.2

Conductivity factor = Electrical conductivity (dS/m per mg N) due to nitrogen salts (from Table A2.1).

Nitrogen Application Rates

The guidelines in Table A2.2 should be used when nitrogen application rates will be equal to or greater than 25 kg/ha. Site-specific nitrogen application rates may also be used, based on a soil fertilizer recommendation determined by a qualified agrologist from soil test data. The land manager should be fully informed of the nitrogen rate applied.

Nitrogen-based waste application rates should be calculated using the following equations.

Equation (17) for oversaturated wastes:

$$\text{Waste application rate} = \frac{\text{N application rate x } 1000}{\text{Waste N concentration x } \Phi} \quad (17)$$

Waste application rate = Waste application rate (m^3/ha)

N application rate = Amount of N applied in waste (kg N/ha) from Table A2.2

Waste N concentration = Sum of all mineral N species (NH_4-N, NO_3-N, NO_2-N) (mg/L)

$$\Phi = \text{Volume fraction of water in waste} = \frac{2.65 - \text{SGfm}}{1.65}$$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

Equation (18) for undersaturated wastes:

$$\text{Application rate} = \frac{\text{N application rate x SLR x } 1000}{\text{Waste N concentration x } (1 - \Phi)} \quad (18)$$

Application rate = Waste application rate (m^3/ha)

N application rate = Amount of N applied in waste (kg/ha) from Table A2.2

SLR = Ratio of solids to liquid in saturated paste extract of waste

$$= \frac{(SGsp - 1)}{(2.65 - SGsp)}$$

SGsp = Specific gravity of a saturated paste made from the waste, measured using an API mud balance

Waste N concentration = Sum of all mineral N species (NH_4-N, NO_3-N, NO_2-N) (mg/L)

Φ = Volume fraction of water in waste = $\frac{2.65 - SGfm}{1.65}$

SGfm = Specific gravity of the field-moist waste, measured using an API mud balance

Table A2.1. Conductivity factors for equation 16

Conductivity factor	
$Ca(NO_3)_2{}^*4(H_2O)$	0.012
KNO_3	0.010
NH_4NO_3	0.0041
$(NH_4)_2SO_4$	0.0076
$NaNO_3$	0.0087

Table A2.2. Recommended nitrogen loading limits (kg N/ha)[1] for landspray, landspray while drilling, disposal onto forested Public Lands, and pump-off[2]

	Cropped, dryland	Cropped, irrigated	Tame forage (including pasture)	Native prairie	Forest
No farmer applied nitrogen	70	140	50	50	200
Farmer applied moderate rate of nitrogen but no soil test	35	70	25	25	n/a
Farmer applied nitrogen to meet soil test recommendation	0	0	0	0	0

[1] Nitrogen loading limits are expressed as the mass (kg) of N per hectare, measured as mineral nitrogen (nitrate+nitrite+ammonia).

[2] Nitrogen loading limits may be adjusted using guidance from Tables 2 and 3 in the Alberta Fertilizer Guide (2004 or as updated by Alberta Agriculture, Food, and Rural Development) and in consultation with the landowner.

A2.4 Lab Protocol for Mixing Drilling Waste with Receiving Soil

Analytical data for lab-made mixtures can be used to estimate mix characteristics after disposal, as well as the minimum soil to waste mix ratio needed in the field in order to meet post-disposal criteria. Good field sampling and submission to the lab of manageable quantities of homogeneous material will reduce discrepancies due to sample variability. An obstacle in the lab to obtaining an accurate estimate of the required mix ratio is the difficulty of reproducing field conditions. Samples of receiving soil are generally disturbed and thus less dense than in the field. Clay samples in particular may be lumpy and have large voids. For this reason, weighing a sample of the receiving soil and assuming a set bulk density

appropriate for the type of soil involved is considered the best way to estimate a desired field condition volume.

A2.4.1 Suggested Protocol

1) Homogenize the moist soil, if necessary, by screening up to 1 kg through 5 mm.

   a) If the waste is undersaturated but moist, screen up to 400 g (5 mm) and dry at 105°C.

   b) If the waste is already completely dry, break it up in a mortar and pestle to pass 5 mm.

   c) Agitate oversaturated wastes that have a separate liquid phase (e.g., shake the container well).

   In all cases, after having homogenized the soil and waste, take the following steps, which are designed to minimize interlab discrepancies, to allow for changes in bulk density during collection and shipping of soil samples and to mirror on-site bulk volume mixing methods:

2) Determine per cent moisture (% moi.) of the soil by drying a subsample at 105°C.

3) Fill a tared, 1 L plastic pail with enough moist soil to make a routine saturated paste.

4) Weigh the pail and contents to determine the moist weight of the soil in it.

5) Calculate dry weight of the soil as follows.

   Dry weight (g) = moist soil weight (g) x (100 - % moisture [as received]) / 100

   or:

   Dry weight (g) = moist soil weight (g) x 100 / (% moisture [dry basis] + 100)

6) Determine the required waste volume to add using the following formula:

   Waste volume (mL) = dry weight of soil (g) / factor

   In the above formula for the required waste volume, the "factor" to use depends on the intended field soil to waste mix ratio, as listed below:

Factor[a]	Mix volume ratio
4.6	3:1
7.7	5:1
10.8	7:1

[a] Factor = mix ratio x undisturbed on-site soil density (default value for mineral soils = 1.54 kg/L). If the receiving soil density is likely to differ substantially from the default value, calculate the appropriate factor using the actual soil bulk density.

7) Measure out the required waste volume, and add it to the soil in the 1 L pail.[1] For undersaturated wastes, use a weight of homogenized, dry waste from step 2(a) or 2(b) corresponding to the required waste volume from step 7, by means of the following equation:

   Dry waste weight (g) = Waste volume (mL) x DBD/1000

   Where DBD = dry bulk density of the waste (in kg/m^3), obtained as described in section A6.4.1(b).

8) Add water and blend so as to bring the mixture to a saturated paste condition. Allow lumps to soak before blending; use an electric blender if desired.

9) Cover the pail loosely and leave the blended mixture at least four hours or preferably overnight (16 hours) to allow soluble salts to approach equilibrium.

10) Blend in more water, if necessary, to re-establish saturation.

11) Measure weight loss (at 105°C) on a subsample of paste to obtain per cent saturation.

12) Record pH of the paste, filter and test filtrate for salinity parameters.

Reference: Ashworth and Webster. 2004. *Proceedings of the 41st Alberta Soil Science Workshop*, pp. 61-67.

[1] Suggestion: Using water (density = 1.00 g/mL) instead of waste, weigh the calculated required volume in a disposable cup, marking the outside of the cup at the water level. Discard the water and add homogenized waste to the mark (settling it by tapping the cup base on the bench top), then transfer the waste into the pail of soil, rinsing the cup with the minimum amount of deionised water.

Appendix 3 Hydrocarbons

A3.1 Introduction

Changes or updates to soil quality or remediation guidelines require that the methods of applying wastes to land be re-evaluated to ensure that the resulting soil/waste mix does not exceed the updated guideline values. From a hydrocarbon perspective, the 1996 edition of *Directive 050* has been revised to ensure that disposal operations meet the AEW *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010). Hydrocarbon endpoints for soils receiving drilling wastes have been established based on these guidelines and are set out in Table 3.2 of this directive.

Hydrocarbon flags remain a valid indicator of the presence of hydrocarbons in drilling wastes. This revision of *Directive 050* requires that drilling wastes be tested for hydrocarbons if hydrocarbon flags have been encountered and that the results be used to make decisions about disposal methods and rates and about the need to sample the resulting waste/soil mix after disposal.

A3.2 Hydrocarbon Flags

Historic scientific data on hydrocarbon contamination in drilling waste were collected as part of an initiative known as the 1994 Drilling Waste Review Project, which took place during an earlier review of *Directive 050.* This information was considered in the development of Appendix 3.

The 1994 information identified that drilling wastes that contained significant hydrocarbon levels came from situations where a hydrocarbon flag was indicated. Wastes generated from a drilling operation are hydrocarbon flagged if

- the well is a horizontal oil well,
- a diesel pill was added,
- any other hydrocarbons were added through drilling practices such as underbalanced drilling or drillstem testing, or
- there are any visible hydrocarbons in the drilling waste.

The AEW document sets out hydrocarbon guidelines for benzene, toluene, ethyl benzene, and xylene (BTEX) and hydrocarbon fractions C_6 to C_{10} (F1), > C_{10} – C_{16} (F2), > C_{16} – C_{34}(F3), and > C_{34}(F4). A review of the 1994 information could not provide an indication as to whether volatile hydrocarbons (BTEX and F1) were a concern. As the guideline values for volatile hydrocarbons are quite low, licensees are cautioned that a visible indicator may not capture BTEX and F1 exceedances.

A3.3 Hydrocarbon Analysis

Earlier versions of *Directive 050* allowed hydrocarbon concentrations within the soil/waste mix to be calculated based on spread rates and the total petroleum hydrocarbon concentration of the drilling waste, but didn't require post-disposal sampling of the soil/waste mix. The current *Directive 050* identifies circumstances in which post-disposal sampling and analysis of the soil/waste mix are required to verify that the hydrocarbon endpoints set out in Table 3.2 have not been exceeded.

Although screening methods can be used to determine the hydrocarbon content in drilling wastes that are hydrocarbon flagged, the procedure and methods set out in AEW *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010 or as updated) must be used to determine hydrocarbon content in soils and soil/waste mixtures (refer to Section 5).

A3.4 Revised Protocol for Disposal of Hydrocarbon-impacted Drilling Wastes

The occurrence of a hydrocarbon flag requires the concentrations of BTEX and F1 to F4 hydrocarbon components within the drilling waste to be determined and used to calculate spread rates that will prevent the receiving soil from exceeding the values in Table 3.2 for the applicable land use and soil type. Post-disposal sampling of the soil/waste mix is required if the concentration of any of the BTEX or F1 to F4 hydrocarbon components within the drilling waste exceeds the values set out in Table 3.3.

The following calculation can be used to predict the concentration of hydrocarbons in the final soil/waste mix, assuming a mix ratio of 1 part waste to 3 parts soil (substitute appropriate numbers for other mix ratios as applicable; refer to Appendix 6 for further calculations):

$$P_m = \frac{P_w \times DBD\ (kg/m^3)}{[3 \times 1540\ (kg/m^3)] + DBD\ (kg/m^3)}$$

where

P_m (mg/kg or %) = parameter concentration in soil/waste mix on a dry weight basis

P_w (mg/kg or %) = parameter concentration in the waste on a dry weight basis

1540 kg/m^3 = receiving soil density (subsoil)

DBD (kg/m^3) = the dry bulk density of the solids or total waste calculated from specific gravity

The hydrocarbon concentrations set out in Table 3.3, which trigger the requirement to post-disposal sample the soil/waste mix, are in mg/kg wet weight and are correlated to the specific gravity (SG) of the drilling waste. The concentrations were calculated using Alberta Tier 1 de-minimus soil guideline values (2010) for the hydrocarbon components and a soil to waste mix ratio of 3 to 1. The following calculations were used:

Hydrocarbon concentration (mg/kg) = Tier 1 criterion x factor

where

Factor = [(Mix ratio of 3 x 1540) + DBD)] / Wet Density

Appendix 4 Metals

A4.1 Introduction

Changes or updates to soil quality or remediation guidelines require that the methods of applying wastes to land be re-evaluated to ensure that the resulting soil/waste mix does not exceed the updated guideline values. From a metal perspective, the 1996 edition of *Directive 050* has been revised to ensure that disposal operations meet the AEW *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010) or, if applicable, the AEW *Soil Remediation Guidelines for Barite* (2009) (refer to Section 3.4 for guidance on using the barite guidelines). Metal endpoints for soils receiving drilling wastes have been established based on these documents and are set out in Table 3.4.

A4.2 Rationale for Including/Excluding Metals

A number of drilling fluid additives/mud products are used to ensure that the fluid properties are compatible with the geological conditions encountered during drilling. These fluid additives/mud products may contain metals and, depending on the quantities used, may be the source of metal issues. Historic data on metal concentrations in drilling waste collected as part of the 1994 Drilling Waste Review Project concluded that metal analysis of drilling waste was only required when fluid additives/mud products containing significant metal concentrations were added to the drilling mud system.

Metal sources of concern include, but are not limited to, the following:

- zinc carbonate ($ZnCO_3$), which is commonly used to remove hydrogen sulphide if it is encountered during drilling. In some cases, $ZnCO_3$ is contaminated with cadmium. If the drilling waste needs to be analyzed for $ZnCO_3$, cadmium should also be measured;
- barite ($BaSO_4$), which is used to increase fluid density; and
- chrome lignosulphonates, which were commonly used as thinners at one time, but have been largely phased out.

Drilling wastes must continue to be analyzed for metals when the cumulative concentration of metals in the fluid additives/mud products added to the drilling mud system exceeds the values for any of the metals in Table 3.4. The entire mud list must be reviewed and all of the additives/products containing the metals listed in Table 3.4 must be considered when determining the need to analyze the drilling waste. Metal data for additives/products must be gathered from material safety data sheets or other product specification information obtained from the additive/product manufacturer. If there is not sufficient information to determine the metal concentration in all the additives/products used in the drilling mud system, the drilling waste must be analyzed for metals. Licensees can also obtain metal information for a drilling mud system by developing and analyzing a "generic mud system" as described in Section 4.4. The results of the metal analysis of the drilling waste must be used to calculate appropriate soil/waste mix or spread ratios to ensure that the soil endpoints set out in Table 3.4 are not exceeded.

The following can be used to calculate the concentration of a metal after mixing the drilling waste with the receiving soil, assuming a mix ratio of 1 part waste to 3 parts soil (substitute appropriate numbers for other mix ratios as applicable):

$$P_m = \frac{(P_w \times DBD) + [P_s \times 3 \times 1540\ (kg/m^3)]}{[3 \times 1540\ (kg/m^3)] + DBD\ (kg/m^3)}$$

where:

P_m (mg/kg or %) = parameter concentration in soil/waste mix on a dry weight basis

P_w (mg/kg or %) = parameter concentration in the waste on a dry weight basis

P_s (mg/kg or %) = parameter concentration in the soil on a dry weight basis

1540 kg/m^3 = receiving soil density (subsoil)

DBD (kg/m^3) = the dry bulk density of the solids, or total waste calculated from specific gravity

The metal concentrations set out in Table 3.5, which trigger the requirement to post-disposal sample the soil/waste mix, are in mg/kg wet weight and are correlated to the specific gravity (SG) of the drilling waste. The concentrations were calculated using Alberta-specific background soil metal concentrations from AEW, Alberta Tier 1 de-minimus soil guideline values (2010) for metals, and a soil to waste mix ratio of 3 to1.

Appendix 5 Toxicity Testing

A5.1 Introduction

A number of drilling fluid additives/mud products are used to ensure that the fluid properties are compatible with the geological conditions encountered during drilling. Some of these fluid additives/mud products may have toxicity concerns. Toxicity testing of drilling wastes can be used to determine whether components that might be harmful to vegetation, micro-organisms, aquatic species, wildlife, or humans and are not detected in routine chemical analysis are present. Toxicity testing can also be useful in predicting the influence of environmental factors on ecotoxic responses and the short- and long-term impacts of drilling wastes.

Toxicity tests that are suited to the testing of drilling waste material must be responsive to components that are organic, metallic, organometallic, or gaseous and should not be highly dependant on major nutrient or ion concentrations.

Toxicity tests are conducted on drilling waste to

- determine the presence or absence of toxicity,
- ascertain the nature, extent, and probable cause of toxicity,
- assist in developing and evaluating waste treatment options, and
- assist in making waste disposal decisions.

An evaluation of potential toxicity is required for the fluids, solids, or total waste components of all drilling wastes. Examining the mud products used and the operations at the well site can provide guidance as to whether toxicity testing is required. When toxic effects are identified, the source of the effects must be identified and properly managed as part of the overall disposal plan.

The 1996 edition of *Directive 050* identified the Microtox® toxicity test, which uses a luminescent bacterium as the test organism, as the established standard for evaluating the toxicity of drilling fluid additives/mud products and the potential toxicity of drilling wastes. This microbial test is used as a cost-effective alternative to the rainbow trout acute lethality test. This edition of *Directive 050* retains the luminescent bacterial toxicity test but also introduces the concept of using terrestrial toxicity testing as an alternative in situations where the luminescent bacteria toxicity test is not suitable for the product/drilling waste being tested (e.g., because of physical interference or atypical dose response).

The following sections are focused on water-based drilling fluids; other mud systems require specific management and disposal plans. The mechanism that will be used to evaluate the toxicity of the system must be addressed in the management plan.

A5.2 Luminescent Bacteria Toxicity Test and Pass Threshold

The 1996 edition of *Directive 050* also described the Microtox® methodology, including the standard assay procedure (SAP; testing an osmotically-adjusted sample at the highest concentration of 45 per cent) and the increased sensitivity assay procedure (ISA; testing an osmotically-adjusted sample at the highest concentration of 81.8 per cent). The directive set a pass threshold of 75 per cent for an EC50(15); i.e., the aqueous concentration of the drilling

waste or drilling fluid additive/mud product that halves the initial light output of the luminescent bacteria after 15 minutes must be 75 per cent or greater.

This edition of *Directive 050* retains the luminescent bacteria toxicity test as a standard, and it retains a pass threshold of 75 per cent for an EC50(15), but it does not include the Microtox® methodology or procedures. See the references below for the methodology and procedures for toxicity testing using luminescent bacteria.

Aqueous phase samples

MicrotoxOmni Software, v. 1.18 ©2003 Strategic Diagnostics Inc. (for additional information call 800 544-8881 or visit www.sdix.com).

American Public Health Association, American Water Works Association, and Water Environment Federation. Method 8050: Bacterial Bioluminescence. *Standard Methods for the Examination of Water and Wastewater*, 21st edition.

Western Canada Microtox Users Committee. *Standard Procedures for Microtox Analysis*. 1994. Report AECV94-G1, available from www.wcmuc.com.

Environment Canada. *Biological Test Method: Toxicity Test Using Luminescent Bacteria*. Report EPS 1/RM/24, 1992.

The Open Environmental Pollution & Toxicology Journal, 2010, Volume 2: 1-7. *Turbidity and Color Correction in the Microtox™ Bioassay*. John Ashworth, Erik Nijenhuis, Bozena Glowacka, Lang Tran, and Lisa Schenk-Watt.

Solid phase samples

Environment Canada. *Biological Test Method: Reference Method for Determining the Toxicity of Sediment Using Luminescent Bacteria in Solid-Phase Test*. Report EPS 1/RM/42, 2002.

A5.2.1 Luminescent Bacteria Toxicity Test Limitations, Interferences, and Sample Handling

Under advisement from the Western Canada Microtox Users Committee, sample preparation techniques specific to the luminescent bacteria test method for the assessment of drilling waste toxicity have been retained in this edition of *Directive 050* and are set out below. However, licensees are reminded of this directive's Section 5, which requires that methods used to assess drilling waste be recognized and published, preferably methods for which SSC or CALA accreditation had been obtained or is expected.

A5.2.2 Luminescent Bacteria Toxicity Test: Limitations and Interferences

Colour (especially red and brown), turbidity, suspended solids, and floating or emulsified substances interfere with this test by absorbing or reflecting light and thereby affecting or causing non-specific reductions in light output. The absorbance (colour) correction procedure should be used to correct for these interferences. The procedure provides a means for mathematically adjusting the light emission readings to account for light lost due to adsorption, and allows the testing of coloured or slightly turbid test samples. Highly turbid or emulsified samples should be clarified as much as possible by centrifuging and decanting prior to testing.

A high salt concentration in test samples (i.e., in excess of 30 g/L NaCl) may produce hyperosmotic effects upon addition of NaCl as required in the toxicity test. No osmotic adjustment should be made if the salt concentration in the sample is between 30 to 50 g/L NaCl equivalent.

Presence of volatiles may affect the test results or reproducibility. However, unless aeration or excessive mixing is performed on the samples, volatile components should not be excessively lost.

Test sample pH may inhibit light output and affect test results. Ideally, the test sample pH should not be adjusted because the test relevance and sample integrity may become questionable. Altering the test sample pH will usually change the solubility of both organic and inorganic constituents. Modifying the pH can also cause chemical reactions that will change the sample matrix and integrity and greatly alter the exhibited toxicity of the sample. The pH should be adjusted only in samples that have a pH below 6.0 or above 8.8 to minimize any potential effects due to pH alone.

A5.2.3 Luminescent Bacteria Toxicity Test: Fluids Sample Handling–Clarification

Drilling waste material will be in one of three phases: fluid, sludge, or solid. In practice, samples cannot be neatly categorized as they may range from clear liquids to slightly turbid waste, to highly turbid waste, to thick sludge, to solids.

The toxicity test must be performed on a liquid portion of the samples as received. In order to match on-site disposal as far as possible, toxicity testing in the laboratory should be done with the minimum of sample preparation. Turbidity/colour-correction procedures must accurately correct for any effects on apparent sample toxicity caused by colour and/or sample turbidity (measured in Nephelometric Turbidity Units, NTU).

A5.2.4 Luminescent Bacteria Toxicity Test: Solids Sample Handling–Aqueous Extraction Procedure

The testing of solids samples, such as thick sludges, solids, and drill cuttings, will require the preparation of an aqueous extract prior to toxicity testing as follows:

1) Perform a 1:1 extraction as follows:

   a) to 25 g of the solids sample as received, add 25 mL of demineralized water in a clean glass container, and

   b) close the container with a Teflon-lined cap or parafilm.

2) Place the container on a wrist-action shaker at the maximum mixing arc for one hour. If a wrist-action shaker is unavailable, a suitable mechanical shaker may be used, providing there is complete mixing between the solid and fluid phases. Ensure that the maximum surface contact is obtained. Record the type of shaker used (this is not required to be reported but is used for interpreting and comparing results).

3) Transfer the aqueous extract solution to a glass centrifuge tube using a glass pipette. If glass centrifuge tubes are unavailable, nontoxic plastic tubes may be used. Record the type of centrifuge tube used (this is not required to be reported but is used for interpreting and comparing results).

4) Clarify the extract by centrifuging at 16 000 × g for 10 minutes in a refrigerated centrifuge at approximately 10 to 15°C, if possible. If refrigerated centrifuge at this g-force is unavailable, cool the sample to 10°C prior to centrifugation at the maximum attainable g-force for your centrifuge. Record the speed, g-force, and temperature used for centrifugation. If the aqueous phase does not appear clear after centrifugation, re-centrifuge in a clean centrifuge tube. (The sample should be clarified so that colour correction has little or no effect.)

5) Immediately transfer the aqueous supernatant to a clean glass container. Close the container with a Teflon-lined cap.

A5.2.5 Luminescent Bacteria Toxicity Test—Drilling Waste Charcoal Treatment Procedure

Drilling wastes that demonstrate a toxic response to luminescent bacteria should have a sample of it retested after being treated with charcoal to identify whether hydrocarbons are contributing to the observed toxicity or whether further characterization is required to determine the source of toxicity (refer to Section 4.3, points 5 through 9). Understanding the source of toxicity can provide insight into potential field treatment methods that could be used to reduce the toxicity of the drilling waste.

Charcoal treatment will help determine whether the toxic components will adsorb in similar environmental conditions following disposal. (This treatment has historically been used to successfully remove hydrocarbon contamination from a sample, but it should not be considered solely indicative of hydrocarbon contamination.)

In order to achieve comparable results for charcoal treatment of drilling wastes, it is imperative that lab analysis adhere to the following procedures. Any deviation from these procedures would result in invalid results.

Preparation of Charcoal

1) Use a good quality, granular-activated charcoal, such as bone- or hardwood-derived charcoal suitable for use in fish aquariums, 10 to 20 mesh size. The use of Nuchar or other powder forms of charcoal is not acceptable

2) Prewash the charcoal by placing about 2 kg in a plastic colander or fine nylon mesh sieve and rinsing for several minutes with hot tap water followed by high-purity demineralized water. Ensure that all charcoal fines are removed during this step. Repeat rinsing step, if necessary.

3) Dry the washed charcoal at 105°C in a clean, organic-vapour-free drying oven for 16 hours.

4) Cool to room temperature and store in a clean, tightly-closed glass container.

Charcoal Treatment Procedure

1) Transfer 5 mL of a clarified, pH-adjusted sample into a clean 10 mL glass test tube fitted with a polyethylene cap.

2) Add 0.60 g of prepared activated charcoal.

3) Shake tube gently for about 10 seconds every 2 minutes for a total of 10 minutes.

4) Allow the charcoal to settle for 30 minutes. Do not allow the settling time to extend past 30 minutes. Shake the tube gently.

5) Perform the toxicity test on the sample, following the SAP or ISA procedure.

Quality Control for Charcoal Treatment Procedure

1) Test the prewashed activated charcoal for the presence of toxicants on a regular basis by substituting high-purity, toxicant-free demineralized water for the test sample and following the charcoal treatment procedure described above

2) Perform the toxicity test on the charcoal-treated demineralized water and the untreated demineralized water (as an analytical blank).

3) Follow this quality control procedure whenever charcoal treatment is used.

A5.3 Alternative Toxicity Testing

The luminescent bacteria toxicity test may not be suitable for testing all drilling mud products and drilling wastes. Certain categories of products, such as starches or those that are insoluble, yield atypical dose responses with the luminescent bacteria and do not allow an accurate endpoint for the products to be established. Terrestrial toxicity testing is an additional step in the toxicity assessment process and can be used to

- provide soil toxicological data on the effect of a known concentration of a mud product/additive on plants and invertebrate species native to Alberta;
- establish a threshold toxicity level for mud products/additives. The proponent must provide information to support the claim that luminescent bacteria toxicity testing is not suitable for the mud product/additive; or
- assess the potential to land-apply drilling wastes.

The strength of terrestrial toxicity tests is that organisms from different terrestrial trophic levels are used to assess toxicity and the appropriateness of land application of drilling wastes. The specific procedures for terrestrial toxicity testing of fluid additives/mud products or drilling wastes are outlined in the following Environment Canada soil toxicity test methods, which must be used to develop a plan for approval of land application of the drilling wastes:

- *Test for Measuring Emergence and Growth of Terrestrial Plants Exposed to Contaminants in Soil* (Report EPS 1/RM/45, 2005);
- *Test for Measuring Survival and Reproduction Effects in Springtails Exposed to Contaminants in Soil* (Report EPS 1/RM/47, 2007); and
- *Tests for Toxicity of Soil Contaminants to Earthworms* (Eisenia Andrei, Eisenia fetida or Lumbricus terrestris) (Report EPS 1/RM/43, 2004).

The plan should include the development of a suitable matrix that reflects conditions in the field. The matrix, therefore, should be a blend of 1 part product, mud system, or drilling waste to 3 parts soil. Incorporation of waste into artificial or site-referenced soil is allowed. However, use of artificial soil following the recipe outlined in the Environment Canada methods will reduce variability in sample handling, allow standardized base soil to be used

between labs, and allow any effects observed to be discerned from the product or waste being tested rather than from natural impairment that might be imparted from the site soil.

The Environment Canada soil toxicity test methods use inhibition concentration causing 50 per cent effect on exposed test organisms (IC50) as a principal endpoint. IC50 is used when quantitative (or continuous) data is being analyzed (i.e., growth or reproduction), whereas LC50, the concentration of material in water, soil, or sediment that is estimated to be lethal to 50 per cent of the test organisms, and EC50 are statistical endpoints for tests using a quantal (or count) type approach (i.e., survival, avoidance behavior). Further explanation on this matter, as well as on statistical methods of analyzing toxicity test data, can be found in the Environment Canada *Guidance Document on Application and Interpretation of Single-species Tests in Environmental Toxicology* (Report EPS 1/RM/34, 1999) and *Guidance Document on Statistical Methods for Environmental Toxicity Tests* (Report EPS 1/RM/46, 2005).

Other references related to soil and toxicity assessment include:

- *Alberta Tier 1 Guidelines for Soil and Groundwater Remediation*. 2007a, Alberta Environment;
- *Alberta Tier 2 Guidelines for Soil and Groundwater Remediation*. 2007b, Alberta Environment;
- *A Protocol for the Derivation of Human Health and Ecological Soil Quality Guidelines*. 2006, Canadian Council of Ministers of the Environment (CCME), PN 1332;
- *Canada-Wide Standards for Petroleum Hydrocarbons (PHCs) in Soil*. 2007, Canadian Council of Ministers of the Environment (CCME), Draft; and
- *Tier 2 Eco-contact Guideline Derivation Protocol*. 2007, Alberta Environment, Draft.

The onus is on licensees to obtain toxicity testing information for fluid additives/mud products used in the drilling mud formulation. In situations where luminescent bacteria toxicity information is not available, the licensee must develop a toxicity testing program and gather the data to develop toxicity threshold levels that would be equivalent to those developed using the luminescent bacteria testing method. This program must be provided to the ERCB for review and approval before implementing it.

In situations where the reason why the drilling waste failed the luminescent bacteria bioassay cannot be determined and the licensee wishes to land-apply the drilling waste, the onus is on the licensee to develop a toxicity testing program and gather the data to support that the disposal of the drilling waste is not toxic to the soil environment. Information to support that the soil/waste mix does not exceed the salt, hydrocarbon, and trace element endpoints set out in Section 3 of this directive must be evident before proceeding to the development of a terrestrial bioassay program. This program must be provided to the ERCB for review and approval before it is implemented.

Appendix 6 Drilling Waste Sample Handling, Analytical Methods, and Calculations

A6.1 Introduction

Analyses must be done to obtain the data required to develop drilling waste treatment and/or management plans. Background soil conditions must be assessed to determine whether a site is appropriate to manage drilling wastes. The resulting data, along with the drilling waste assessment data, must be used to predict a drilling waste spread rate that will prevent the soil/waste mix from exceeding the salt, hydrocarbon, and trace element soil quality endpoints set out in Tables 3.1, 3.3, and 3.4 in Section 3 of this directive. In some situations, the resulting soil/waste mix must be sampled and analyzed to confirm that the predicted drilling waste spread rates were appropriate.

A6.2 Sample Handling and Preparation

Drilling wastes are rarely collected in a saturated condition, where the pores of the solids are full of liquids but there is no excess liquid. Drilling wastes are usually collected in an oversaturated condition, where the pores of the solids are full and there is excess liquid. Occasionally an undersaturated condition occurs, where not all of the pores of solids are filled with liquid.

Sample handling and preparation differ depending on whether the drilling waste is undersaturated or oversaturated. Drilling waste fluids and total waste samples are typically oversaturated, whereas drilling waste solids can be undersaturated.

The phase that is analyzed depends upon the parameter. Oil content and metal analysis must be done on the whole sample and not on the individual phase. Analysis of soluble parameters must be done on the liquid phase of an oversaturated sample or a saturated paste extract of an undersaturated sample.

The following provides guidance for sample preparation for analysis of soluble parameters.

Fluids Sample: Sample preparation depends on the method of analysis. As a minimum, the fluids sample should be clarified by filtration or centrifuging to pass through a Whatman No. 1 (11 micron) filter paper or equivalent to remove any solids. Further clarification may be necessary.

Clear Liquids Sample: The sample should already be clear. However, to remove any floating particles the sample should be clarified by filtration or centrifuging to pass through a Whatman No. 1 filter paper or equivalent. The analysis will be done on the clarified extract.

Solids Sample: An oversaturated solids sample should be clarified by filtration or centrifuging to pass through a Whatman No. 1 filter paper or equivalent. The analysis will be done on the clarified extract. Drying, grinding, sieving, and rewetting into a saturated paste is not required.

An undersaturated solids sample should be brought to a saturated paste condition by adding distilled water and mixing thoroughly. After standing for a **minimum of four hours**, the analysis will be done on the saturated paste extract.

Total Waste Sample: As a minimum, the sample should be clarified by filtration or centrifuging to pass through a Whatman No. 1 filter paper or equivalent. Drying, grinding, sieving, and rewetting into a saturated paste is not required.

Oil content and metals analysis must be done on the whole sample and not on the individual phase.

Composite Waste Samples—Landspraying Disposal Method: The landspraying composite waste sample should be clarified by filtration or centrifuging to pass through a Whatman No. 1 filter paper or equivalent. Drying, grinding, sieving, and rewetting into a saturated paste is not required.

Receiving Soil Sample: The soil sample can be either dried and ground and a saturated paste prepared or a moist subsample can be brought to a saturated paste condition (drying, grinding, sieving, and rewetting into a saturated paste is not required). The paste must be allowed to equilibrate for at least four hours.

To compare analyte concentrations in soil, drilling wastes, and drilling waste/soil mixes with regulatory limits or endpoints, they must be expressed on a dry weight basis. Dry bulk density (DBD), the dry weight of solids in a given volume of wet waste, is determined from the specific gravity (SG) and is used to calculate concentrations on a dry weight basis.

A6.2.1 Specific Gravity

SG measurements of fluids, solids, and total wastes are required for calculating the DBD and the volume fraction of water.

The SG is measured using an API mud balance or equivalent.

a) Oversaturated Drilling Wastes

The SG is measured after adding the as-received fluid, solid, or total waste to the API mud balance cup so as to fill it completely. This value is used to calculate the mud density, the DBD, and the volume fraction of water (Φ).

b) Undersaturated Drilling Wastes

The SG is measured after filling the API mud balance cup with the as-received solid without significantly compressing the sample, and adding water to the cup to fill any pore spaces. This first SG value is used to calculate the mud density and DBD.

A separate SG measurement is required on a saturated paste prepared from an undersaturated solid. This second SG value is used to calculate the volume fraction of water (Φ_U) and the concentrations of analytical parameters in mg/kg.

A6.2.2 Major Ion Analytes

Analysis for electrical conductivity, sodium adsorption ratio (sodium, calcium, magnesium), chloride, and forms of nitrogen in oversaturated drilling waste samples are to be done on an as-received filtrate. The drilling waste samples are to be clarified by filtration or centrifuging to pass through a Whatman No. 1 filter paper or equivalent; the analyses are to be done on the clarified filtrate.

Major ion analysis of undersaturated drilling waste or soil samples is to be done on a saturated paste extract.

Nitrogen analysis must include both the ammonia-nitrogen and nitrate-nitrogen forms.

A6.2.3 Trace Elements and Hydrocarbons

Trace element and hydrocarbon content analyses of drilling waste solid samples and total waste samples are to be done on the samples as received. Although screening methods can be used to determine the hydrocarbon content in drilling waste samples, the procedure and methods set out in the Alberta Environment *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (2010 or as updated) must be used to determine hydrocarbon content in soils and soil/waste mixtures. Hydrocarbon analysis of drilling waste fluids samples are done on as-received samples.

A6.2.4 Toxicity Assessment

Toxicity assessment using the luminescent bacteria bioassay must be done following the references provided in Appendix 5.

A6.3 Calculations

A6.3.1 Calculations for Drilling Wastes

The following calculations can be used to determine the concentration of a parameter on a dry weight basis or the total mass of a parameter in a volume of drilling waste.

a) Oversaturated Drilling Waste Materials Equations

The DBD of oversaturated solids or total waste is calculated by measuring the SG of the wet solids using an API mud balance.

$$\text{DBD (kg/m}^3\text{)} = \frac{|\text{Measured mud density (kg/m}^3\text{)} - 1000\ \text{(kg/m}^3\text{)}| \times 2.65\ \text{(g/mL)}}{2.65\ \text{(g/mL)} - 1\ \text{(g/mL)}}$$

where

DBD = dry weight of solids in a given volume of wet waste

Measured mud density (kg/m^3) = SG x 1000

2.65 (g/mL) = particle density of solids

Density of water = 1000 kg/m^3 = 1 g/mL

To convert a parameter from mg/L of filtrate from the as-received (oversaturated) sample to mg/kg of dried waste solids:

$$P_w\ \text{(mg/kg)} = P_{\text{filtrate}}\ \text{(mg/L)} \times \left[\frac{(2650 - \text{DBD})}{(2.65 \times \text{DBD})}\right]$$

where

P_w (mg/kg) = the concentration of the parameter in the dried waste solids

P_{filtrate} (mg/L) = the concentration of the parameter in the as-received filtrate

DBD (kg/m^3) = the dry bulk density (from above calculation)

2.65 (g/mL) = particle density of solids

2650 = 2.65 x 1000

To determine the volume fraction of water in as-received (oversaturated) waste materials:

$$\text{Volume fraction of water } (\Phi) = 1 - \left[\frac{\text{Mud density} - 1000}{1650}\right]$$

where

Mud density (kg/m^3) = SG x 1000

b) Undersaturated Drilling Waste Materials Equations

The DBD of an undersaturated sample is estimated using the same equation as for an oversaturated sample; however, the SG is measured as described in subsection A6.2.1.

Analysis of undersaturated solids requires, as a separate, additional step, the preparation of a saturated paste as follows:

1) Add distilled water to bring a subsample to a saturated paste condition, mix and allow to sit for a minimum of four hours so that the salts can equilibrate with the added water

2) Determine the SG of the saturated paste using the API mud balance.

3) Filter the saturated paste and analyze the extract for major ions and nitrogen, if required.

To determine the volume fraction of water in a saturated paste made from an undersaturated waste material:

$$\text{Volume faction water } (\Phi_U) = \frac{(2.65 - SG)}{1.65}$$

where

SG = specific gravity of the saturated paste is measured using the API mud balance

2.65 (g/mL) = particle density of solids

To convert a parameter from mg/L of filtrate from a saturated paste extract to mg/kg of dried waste solids:

$$P_w \text{ (mg/kg)} = P_{filtrate} \text{ (mg/L)} \times \left[\frac{\Phi_U}{2.65 \times (1 - \Phi_U)}\right]$$

where

P_w (mg/kg) = the concentration of the parameter in the dried solids

$P_{filtrate}$ (mg/L) = the concentration of the parameter in the saturated paste filtrate

Φ_U = the volume fraction of water

2.65 (g/mL) = particle density of solids

c) Equations to Predict the Mass of a Parameter in Drilling Wastes

To predict the mass of trace elements in a given volume of either **oversaturated or undersaturated waste material**:

$$\text{Mass (kg)} = \frac{P_w \text{ (mg/kg)} \times \text{DBD (kg/m}^3\text{)} \times \text{Volume (m}^3\text{)}}{10^6 \text{ (mg/kg)}}$$

where

P_w (mg/kg) = the concentration of the parameter in the dried solids

DBD (kg/m^3) = dry bulk density calculated from SG

Volume (m^3) = volume of drilling waste material

To calculate the mass of a parameter in a given volume of a **clear waste liquid**:

$$\text{Mass (kg)} = P_L \text{ (mg/L)} \times \left[\frac{\text{Clear waste liquid volume (m}^3\text{)}}{1000} \right]$$

where

P_L (mg/L) = the concentration of the parameter in the clear waste liquid

A6.3.2 Disposal Limit Equations

The following calculations can be used to predict soil/waste mix ratios, maximum waste application rates, minimum disposal areas, amount of a parameter per hectare of land, and amount of a parameter in the resulting soil/waste mix. For all salinity equations see Appendix 2.

a) MBC Equations

To calculate the concentration of any parameter in the soil/waste mixture for a mix ratio of 1 part waste to 3 parts soil (substitute appropriate numbers for other mix ratios as applicable) when, for practical purposes, it can be assumed that the receiving soil contains none of that parameter (e.g., hydrocarbon):

$$P_m = \frac{P_w \times \text{DBD (kg/m}^3\text{)}}{[(3 \times 1540 \text{ (kg/m}^3\text{)}] + \text{DBD (kg/m}^3\text{)}}$$

where

P_m (mg/kg or %) = parameter concentration in soil/waste mix on a dry weight basis

P_w (mg/kg or %) = parameter concentration in the waste on a dry weight basis

1540 kg/m^3 = receiving soil density (subsoil)

DBD (kg/m^3) = the dry bulk density of the solids or total waste calculated from SG

To calculate the concentration of a parameter after mixing when the receiving soil already contains a background level of that parameter (i.e., a trace element) for a mix ratio of 1 part waste to 3 parts soil (substitute appropriate numbers for other mix ratios as applicable):

$$P_m = \frac{[P_w \times \text{DBD (kg/m}^3)] + [P_s \times 3 \times 1540 \text{ (kg/m}^3)]}{[3 \times 1540 \text{ (kg/m}^3)] + \text{DBD (kg/m}^3)}$$

where

P_m (mg/kg or %) = parameter concentration in soil/waste mix on a dry weight basis

P_w (mg/kg or %) = parameter concentration in the waste on a dry weight basis

P_s (mg/kg or %) = parameter concentration in the soil on a dry weight basis

1540 kg/m^3 = receiving soil density (subsoil)

DBD (kg/m^3) = the dry bulk density of the solids or total waste calculated from SG

b) Equations for Landspreading, Landspraying, Disposal onto Forested Public Lands, Landspray While Drilling, and Land Treatment

To calculate the maximum application rate that will not exceed the kg/ha loading limit for a given parameter (e.g., sodium):

$$\text{Maximum application rate (m}^3\text{/ha)} = P_{max} \text{ (kg/ha)} \times \left[\frac{10^6 \text{ (mg/kg)}}{P_w \text{ (mg/kg)} \times \text{DBD (kg/m}^3\text{)}} \right]$$

where

P_{max} (kg/ha) = the maximum amount of a parameter (limit) allowed on 1 ha

P_w (mg/kg) = the concentration of a parameter in the dry solids (calculated from filtrate results)

DBD (kg/m^3) = the dry bulk density of the solids or total waste calculated from SG

To calculate maximum application thickness (cannot exceed one-third of the incorporated depth or 10 cm, whichever is less):

$$\text{Maximum application thickness (cm)} = \frac{\text{Maximum application rate (m}^3\text{/ha)}}{100}$$

To calculate the minimum area required for disposal so that the limit for a given parameter (e.g., sodium) is not exceeded, substitute (a) the maximum calculated application rate, (b) 1000 m^3/ha, or (c) incorporated depth (cm)/3 x 100, whichever is less, into the equation below. Licensees are encouraged to use more than the minimum area, if available.

$$[1]\text{Minimum disposal area (ha)} = \frac{\text{Volume of undersaturated solids } (m^3)}{\text{(a) or (b) or (c)}}$$

To calculate the amount of any parameter added to the receiving soil:

$$\text{Amount (kg/ha)} = \frac{P_w \text{ (mg/kg)} \times \text{DBD } (kg/m^3) \times \text{Maximum application rate } (m^3/ha)}{10^6 \text{ (mg/kg)}}$$

where

P_w (mg/kg) = the concentration of a parameter in the dry solids (calculated from filtrate concentrations)

DBD (kg/m^3) = dry bulk density calculated from SG

Maximum application rate (m^3/ha) = value calculated from the above equation

To calculate the amount per hectare of any parameter added to the receiving soil:

$$\text{Amount (kg/ha)} = \frac{\text{Mass of the parameter (kg)}}{\text{Planned disposal area (ha)}}$$

c) Equation Specific for Landspraying and Landspray While Drilling

To calculate the maximum application rate that will not exceed 6 t/ha loading limit for landspraying and landspray-while-drilling disposal methods:

$$\text{Maximum application rate } (m^3/ha) = \frac{6 \text{ (t/ha)} \times 1000 \text{ (kg/t)}}{\text{DBD } (kg/m^3)}$$

where

DBD (kg/m^3) = dry bulk density calculated from SG of the oversaturated solids or total waste

d) Pump-off Equations

To calculate the maximum application rate of clear drilling waste liquid that will not exceed the rate limitation for a dissolved parameter:

$$\text{Maximum application rate } (m^3/ha) = \frac{P_{max} \text{ (kg/ha)} \times 10^{-3} \ (m^3/L) \times 10^6 \text{ (mg/kg)}}{P_L \text{ (mg/L)}}$$

where

P_{max} (kg/ha) = the maximum application rate allowed on 1 ha of land

P_L (mg/L) = the concentration of the parameter in the clear waste liquid

If the calculated rate is greater than 1000 m^3/ha, apply the clear waste liquid at a maximum rate of 1000 m^3/ha. This is equivalent to a 10 cm layer of application.

To calculate the minimum area required for disposal of clear waste liquid without exceeding the parameter limit, substitute (a) the maximum application rate or (b) 1000 m^3/ha, whichever is less, into the equation below. Licensees are encouraged to use more than the minimum disposal area, if it is available.

$$[1]\text{Minimum disposal area (ha)} = \frac{\text{Volume of clear waste liquids } (m^3)}{\text{(a) or (b)}}$$

To calculate the amount per hectare of any dissolved parameter added to the receiving site:

$$\text{Amount (kg/ha)} = P_L \text{ (mg/L)} \times \left[\frac{\text{Application rate } (m^3/ha)}{1000} \right]$$

where

P_L (mg/L) = the concentration of the parameter in the clear waste liquid

[1]NOTE: Where applicable, a simple approach to determine minimum disposal area may be to divide the waste volume by the maximum application rate equation.

Appendix 7 Definitions of Terms as Used in *Directive 050*

Advanced gel chemical	Water-based drilling mud system in which a significant primary component such as salt or polymer has been added to aid in the drilling. Examples include potassium silicate, potassium sulphate, potassium nitrate, and amines.
Alternative storage system	Aboveground tanks or other storage vessels, sumps lined with a synthetic liner, or other storage system approved by the ERCB used to store drilling wastes.
Approved waste management facility	A facility that is approved under the *Oil and Gas Conservation Act* and the regulations under that act or that is approved under the *Environmental Protection and Enhancement Act* and the regulations under that act to process, treat, dispose of, store, or recycle wastes.
Atterberg limits	The Atterberg limits are a basic measure of the nature of a fine-grained soil. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic, and liquid. In each state, the consistency and behaviour of a soil is different and thus so are its engineering properties. The Atterberg limits can be used to distinguish between silt and clay, and it can distinguish between different types of silts and clays.
Bentonite	A type of clay; the main constituent used in freshwater gel drilling mud systems.
Berm	A raised earthen barrier constructed of clayey soils used for containment.
Bioassay	The assessment of a potential biological impact of a substance by quantifying its effect on a representative test organism employing a standardized protocol.
BTEX	Collective abbreviation for the light-end volatile hydrocarbons benzene (B), toluene (T), ethylbenzene (E), and xylenes (X).
Biodegradation	The breakdown of organic contaminants by microbial organisms into smaller compounds. The microbial organisms transform the contaminants through metabolic or enzymatic processes. Biodegradation processes vary, but frequently the final product of the degradation is carbon dioxide or methane.
Bulk density (soil)	The mass of dry soil per unit volume (kg/m^3). The bulk volume is determined before the soil is dried to constant weight at 105°C.
Bulking agent	Material added to increase the surface area of waste. Examples include woodchips, sawdust, and humalite. Note that required characterization, tests, and analyses must be conducted on the drilling waste prior to the addition of bulking agents.
Calculated mix ratio	Soil-to-waste mix ratios determined through the use of calculations listed in Appendices 2, 3, 4, and 6.
Cement returns	Excess cement circulated to the surface after downhole cementing.
Clay	A mineral soil consisting of particles less than 0.002 mm in diameter, a soil textural class, or a fine-grained soil that has a high Plasticity Index relative to the Liquid Limit.

Clayey soil	Soil that has greater than 50 per cent fines (defined as dry weight percentage passing the No. 200 sieve), greater than 20 percent clay (i.e., 0.002 mm or smaller as defined by the hydrometer method), a Liquid Limit equal to or greater than 30 percent, and a Plasticity Index equal to or greater than 10 per cent.
Coarse soil	Soils that have a median grain size greater than 75 microns.
Composite sample	A sample consisting of equal parts of a number of subsamples taken from specific locations/areas/depths such that the composite sample is representative of the whole volume or mass of material being sampled.
Contaminated drilling wastes	Drilling wastes containing materials, other than drilling fluid/mud system, cuttings, formation materials, and precipitation that are foreign to the drilling activity. Examples of contaminant materials include drillstem testing fluids, rig wash fluids, camp wastes, and other oilfield wastes. Contaminated wastes are to be handled following the most restrictive requirements that apply.
Crown disposition	The administrative and operating conditions assigned for use of Public Lands in the form of a lease, licence, permit, or letter of authority; administered by Sustainable Resource Development.
Crown disposition holder	A person or party that has been assigned use of Public Lands (e.g., lease, licence, or permit) issued under the provisions of the *Public Lands Act*.
Cultivated land	Agricultural land that has been worked by plowing and sowing and raising crops.
Cumulative concentration	The calculated value of a substance in a drilling system once all possible sources have been taken into account.
Dilution	Mixing of a liquid or solid (waste) with another liquid or solid for the primary purpose of reducing the concentration of the original liquid or solid. Dilution of wastes to meet disposal criteria is prohibited.
Disposal area	The area of land upon which drilling waste was applied or into which drilling waste was mixed.
Disposal onto forested Public Lands	A drilling waste disposal method that is similar to landspray and landspray-while-drilling but that allows higher application rates and is limited to occur on provincial Crown lands for which SRD has issued specific types of dispositions pursuant to the *Public Lands Act*.
Disposal site	The land used for disposal of wastes.
Dissolved hydrocarbons	Hydrocarbons partitioned into the water phase of drilling wastes.
Drilling cuttings	The small pieces of formation rock and subsurface materials that break away because of the action of drill bit teeth as a well or direction borehole is being drilled.

Drilling mud	A suspension, usually in water but sometimes in oil (diesel), used in rotary drilling, consisting of various substances in a finely divided state (commonly bentonitic clays and chemical additives), introduced continuously down the drill pipe under pressure and through openings in the drill bit and transported back up in the annular space between the pipe and the walls of the hole to a surface pit or tank where it is conditioned and reintroduced into the wellbore. It is used to lubricate and cool the bit, carry the cuttings up from the bottom, and prevent blowouts and cave-ins.
Drilling waste	The muds and cuttings generated while drilling a well and by directional drilling for the purpose of pipeline construction.
Drilling waste clear liquids	Liquids separating from water-based drilling wastes. The liquids appear nonturbid when sampled at the discharge point and qualify for pump-off. The clear liquids may be colourless or may have natural colour or staining.
Drilling waste fluids	The fluid portion of drilling wastes consisting of a mixture of water, drilling muds, fine cuttings, and additives.
Drilling waste solids	The solids portion of drilling wastes consisting of water, drill cuttings, flocculated bentonite, weighting materials, and other additives.
Drilling waste total waste	The entire volume of drilling waste in a sump or storage system consisting of both the fluids and the solids portions.
Dry bulk density	The weight of dry waste per unit volume of wet waste (kg/m^3).
Earthen-bermed storage system	A type of storage system designed to store drilling waste solids that is an earthen structure built on grade and meets design, construction, and operational requirements of this directive.
EC50(15)	In a luminescent bacterial toxicity test, the effective concentration of a sample that causes a 50 per cent decrease in light output at 15°C after 15 minutes exposure.
Electrical conductivity	The ability of a solution to carry an electrical current. Refers to the specific electrical conductance of the water, which is a function of the total dissolved solids. High salinity (high EC) affects plant growth and soil quality.
Endpoint	Maximum concentration of a parameter in soil that has received drilling waste (refer to Tables 3.1, 3.2, and 3.4).
Environment	All components of the earth and includes i) air, land, and water, ii) all layers of the atmosphere, iii) all organic and inorganic matter and living organisms, and iv) all interacting natural systems that include components referred to in subclauses (i) to (iv).
Equivalent land capability	The ability of land to support various land uses, after conservation and reclamation, that is similar to the ability that existed prior to an activity being conducted on the land, but the individual land uses will not necessarily be identical.
Expectations	Recommended best practices or guidelines. Enforcement is not assigned to expectations, but they should be given serious consideration.

Fine soil	Soils that have a medium grain size less than 75 microns.
Flocculant	A chemical used to precipitate or coagulate compounds out of solution. Most flocculants are either multivalent cations, such as calcium, magnesium, and aluminum, or long-chain polymers. Often added to remove fines from drilling fluids.
Fluid additive	A material added to a drilling fluid/mud system to perform one or more specific functions, such as weighting agents, viscosifiers, lubricants, corrosion inhibitors, defoamers, emulsifiers, foaming agents, shale control inhibitors, and surfactants.
Freeboard	The unused upper portion of a primary containment device.
Grain size	The average size in microns of mineral particles making up soil.
Groundwater	Subsurface water beneath the water table in soils and geological formations that are saturated.
Hydrocarbon-based drilling muds	A mud system in which the external phase is a hydrocarbon (e.g., invert, HT40N, mineral oil).
Hydrocarbon flags	Hydrocarbon flag means any situation that could introduce hydrocarbons into a water-based drilling waste, including the well being a horizontal oil well, the addition of a diesel pill, the addition of other hydrocarbons through drilling practices, such as underbalanced drilling or drillstem testing, and hydrocarbons being visible in the drilling waste.
Incorporation	An operational method in which the drilling waste is assimilated into the soil structure, preventing potential migration. This is accomplished by mechanically combining the drilling waste into a consistent soil and waste mixture.
Landowner	The person in whose name a certificate of title has been issued, pursuant to the *Land Titles Act*, or if no certificate of title has been issued, the Crown or other body administering the land. In the case of Métis land, the person registered in the Métis Settlements Land Registry as owner of the Métis title, pursuant to the *Métis Settlement Lands Registry Regulation*.
Landspray	A drilling waste disposal method that involves the dispersion of drilling waste fluids or total waste onto a field by spraying it at a specified, constant rate from a vacuum truck or similar equipment.
Landspray-while-drilling	A drilling waste disposal method that is similar to landspray but that is limited to nontoxic, water-based drilling muds allowing for the testing requirements to be reduced and the disposal to proceed without first storing the drilling waste.
Landspread	A drilling waste disposal method that involves the spreading and incorporation of drilling waste solids or total waste into shallow subsoil with a backhoe or similar equipment.
Land treatment	A planned, controlled mixing of oilfield or drilling wastes and soil in which the inherent soil processes are used to biodegrade, transform, and assimilate the waste constituents.

Licensee	The holder of a licence according to the records of the Board and includes a trustee or receiver-manager of property of a licensee.
Limiting parameter	The analyte that provides the greatest restriction for a disposal method.
Liquid Limit	The liquid limit (LL) is the water content at which a soil changes from plastic to liquid behaviour.
Major ions	General term referring to water-soluble ions (includes anions and cations).
Mix-bury-cover	A drilling waste disposal method that involves the spreading and incorporation of drilling waste solids or total waste into subsoil at a depth of 1 m or more and covering the resulting mix with a minimum 1 m of clean fill/subsoil.
Mud product	A material added to a drilling fluid/mud system to perform one or more specific functions, such as weighting agents, viscosifiers, lubricants, corrosion inhibitors, defoamers, emulsifiers, foaming agents, shale control inhibitors, or surfactants.
Mud density	The weight of a given volume of drilling mud. Usually expressed in kg/m^3.
Off-site	The management of drilling waste on an area of land outside of the boundaries of the well site, pipeline right-of-way, or a remote site.
Oilfield waste	An unwanted substance or mixture of substances that result from the construction, operation, abandonment, or reclamation of a facility, well site, or pipeline, but does not include an unwanted substance or mixture of substances from such sources that is received for storage, treatment, disposal, and/or recycling at a facility regulated by Alberta Environment.
On-site	The management of drilling waste on the well site, pipeline right-of-way, or remote site.
Oversaturated drilling waste sample	A drilling waste sample in which the pores of the solids are full of liquids and there is excess liquid.
Permeability	The property of a porous medium that relates to the ease with which gases or lquids can pass through it.
Per cent moisture	The moisture content of a soil or sediment determined by weighing a subsample of the moist, as-received material and drying it to constant weight (usually at 105°C). The result is reported as a percentage of either the initial moist weight (as-received basis) or the final dry weight (dry weight basis). % moisture (as received) = 100 x weight loss on drying / as-received weight % moisture (dry basis) = 100 x weight loss on drying / oven-dry weight To convert one reported type to another: % moisture (as received) = 100 x % moi.(dry basis) / [100 + % moi.(dry basis)] % moisture (dry basis) = 100 x % moi.(as received) / [100 - %moi.(as received)]

Per cent saturation

The per cent saturation or saturation percentage (% sat.) of a soil is the moisture content of a saturated paste. The per cent saturation value is determined by drying a weighed subsample of the saturated paste of the soil to a constant weight at 105°C.

% sat. = 100 x weight loss on drying / oven-dry weight of paste sample

Petroleum hydrocarbon fraction F1

C_6–C_{10}, excluding benzene, toluene, ethyl benzene, and xylenes (BTEX), as defined by the Canadian Council of Ministers of the Environment (CCME) *Canada-Wide Standards for Petroleum Hydrocarbons in Soil* (2006a).

Petroleum hydrocarbon fraction F2

$C_{>10}$–C_{16}, as defined by the CCME (2006a).

Petroleum hydrocarbon fraction F3

$C_{>16}$–C_{34}, as defined by the CCME (2006a).

Petroleum hydrocarbon fraction F4

$C_{>34}$, as defined by the CCME (2006a).

pH

The degree of acidity or alkalinity of a substance, as measured by the concentration of hydrogen ions. On this scale, pH 1 is a strong acid, pH 14 is a strong alkali, and pH 7 is the point of neutrality.

Plasticity Index

The plasticity index (PI) is a measure of the plasticity of a soil. The PI is the difference between the liquid limit (LL) and the plastic limit (PL) [PI = LL – PL].

Plastic Limit

The plastic limit (PL) is the water content where soil starts to exhibit plastic behaviour.

Pump-off

A drilling waste disposal method that involves pumping the nontoxic, clear liquid portion of drilling wastes onto the surface of land.

Qualified person

For the purpose of verifying the presence or absence of a water body or characterizing and classifying soils, a qualified person is one who possesses post-secondary education in an applicable discipline or educational equivalencies, has technical knowledge and experience in the specific area, and is acting within his/her area of expertise.

Receiving soil

Soils to which drilling wastes are applied.

Remote site

A well site that receives drilling waste from wells located off the well site for the purpose of storage or biodegradation or a stand-alone site that is established specifically to receive drilling waste for the purpose of storage or biodegradation and for which the landowner or department/agency managing the land on behalf of the provincial or federal Crown has provided a written agreement (e.g., surface lease, right of entry, or disposition under the *Public Lands Act*). When more than one well contributes drilling waste to the remote site, the licensee of all of the wells must be the same.

Requirement

A rule that industry has an obligation to meet and under which the ERCB may take enforcement action in cases of noncompliance.

Rig release The date on which all drilling operations are complete and the contractor is released from the well site.

Saline soil A soil with a high content of water-soluble salts and a saturation extract electrical conductivity greater than 4 dS/m. The soil is not sodic.

Saline-sodic soil A soil with a high content of water-soluble salts and high exchangeable sodium. The soil meets definitions of both saline soil and sodic soil.

Saturated zone The saturated zone encompasses the below-ground area in which all interconnected openings within the geologic medium are completely filled with water.

Sodic soil A soil having an exchangeable sodium percentage of 15 or more but is not saline.

Sodium adsorption ratio A calculated ratio used to represent the relative activity of sodium, calcium, and magnesium with respect to ion exchange reactions in soil. A surrogate for exchangeable sodium percentage.

Soil The unconsolidated mineral or organic material at the surface of the earth that serves as a medium for plant growth.

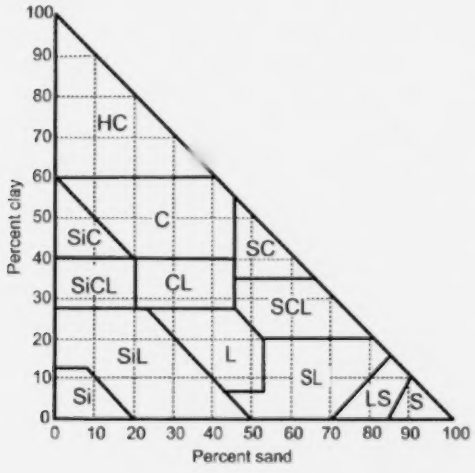
Solid A substance that does not contain free liquids as determined by the US Environmental Protection Agency (EPA) Method 9095 Paint Filter Liquids Test (*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA Publication SW-846) and is not gaseous at standard conditions.

Sorbent material Material added to facilitate waste handling and to manage any interstitial fluids that could shake out during transportation of the waste. Any required characterization, classification, and analyses for a disposal method must be done on the drilling waste prior to the addition of the sorbent material.

Specific gravity The ratio of the density of a substance to the density of water.

Spud The beginning of drilling operations on a well or borehole.

Soil texture The relative proportions of sand, silt, and clay in a soil as described by the classes of soil texture triangle.



Storage system	A type of containment system designed to store materials used, produced, and generated within the upstream petroleum industry and for the purpose of drilling waste, storage systems includes sumps, aboveground tanks and other storage vessels, sumps lined with a synthetic liner, earthen-bermed storage systems, or other storage systems approved by the ERCB.
Sump	A type of storage system designed to store drilling waste that is an earthen excavation and meets the design, contruction, and operational requirements of this directive.
Subsoil	The layer of soil directly below topsoil that consists of the B and C horizons and extends to bedrock. For salinity management, three depths are recognized: top of the subsoil to a depth of 1 m, subsoil from > 1 m to 1.5 m, and subsoil at a depth > 1.5 m.
Tank	A device designed to contain materials produced, generated, and used by the upstream petroleum industry that has an internal capacity of more than 1 m^3 and is constructed of impervious materials that provide structural support and may include materials such as plastic, fibreglass-reinforced plastic, or steel but does not include piping. Refer to *Directive 055* for further requirements.
Topsoil	The uppermost layer(s) of soil that consist of L, F, H, O, and/or A horizons or depth of tillage, whichever is greatest.
Total dissolved solids	The concentration of inorganic or mineral constituents dissolved in water, expressed in mg/L. It may be calculated from electrical conductivity.
Total waste sample	A waste sample from the entire depth of the drilling waste sump or storage system. The fluid and solid phases are collected at the same time using a column sampling tube. The required sample is a composite of subsamples from several locations in the sump or storage system.
Undersaturated drilling waste sample	A drilling waste sample in which the pores of the solids are not full of liquids.
Visible hydrocarbons	The observance of a rainbow sheen on drilling waste (fluid portion, clear liquid portion, or total waste), or a total petroleum content (sum of the concentrations of BTEX and F1 through F4 components) within a drilling waste (fluid portion, clear liquid portion, or total waste) that exceeds 100 mg/L.
Water-based drilling muds	A drilling fluid/mud system in which the external phase is water.

Water body

Natural or manmade; contains or conveys water continuously, intermittently, or seasonally.

A natural water body is any location where water flows or is present, whether the flow or presence of the water is continuous, seasonal, intermittent, or occurs only during a flood. This includes, but is not limited to, the bed and shore of a river, stream, lake, creek, lagoon, swamp, marsh, slough, muskeg, or other natural drainage, such as ephemeral draws, wetlands, riparian areas, floodplains, fens, bogs, coulees, and rills.

Examples of a man-made water body include, but are not limited to, a canal, drainage ditch, reservoir, dugout, or other manmade surface feature.

Waste set

A volume of drilling waste generated from one or more one wells, provided that the generating wells are part of one licensee's drilling program.

Appendix 8 Abbreviations

AEW	Alberta Environment and Water
API	American Petroleum Institute
$BaSO_4$	barite
BTEX	benzene, toluene, ethylbenzene, and xylene
CAEAL	Canadian Association For Environmental Analytical Laboratories
CALA	Canadian Association For Laboratory Accreditation
CCME	Canadian Council of Ministers of the Environment
Cl	chlorine
cm	centimetre
DBD	dry bulk density
DDS	digital data submission system
DFPL	disposal onto forested Public Lands
DST	drillstem testing
DOW	dangerous oilfield waste
dS/m	decisiemen per metre
EC	electrical conductivity
EPA	Environmental Protection Agency
EPEA	Environmental Protection and Enhancement Act
ERCB	Energy Resources Conservation Board
FIS	field surveillance inspection system
g	gram
ha	hectare
ID	interim directive
IL	informational letter
ILAC	International Laboratory Accreditation Cooperation
ISA	increased sensitivity assay procedure
kg	kilogram
L	litre
LCM	Loss circulation materials

LL	Liquid Limit
LOC	licence of occupation
LWD	landspray while drilling
m^2	square metre
m^3	cubic metre
MBC	mix-bury-cover
Mg	magnesium
MGD	minimum-ground-disturbance
mL	millilitre
mm	millimetre
MSDS	material data safety sheets
MSL	mineral surface lease
N	nitrogen
Na	sodium
NaCl	sodium chloride
NTU	Nephelometric Turbidity Unit
PI	Plasticity Index
PLA	pipeline agreement
QA/QC	quality assurance/quality control
SAP	standard assay procedure
SG	specific gravity
SAR	sodium adsorption ratio
SCC	Standard Council of Canada
SRD	Sustainable Resource Development
t	tonnes
UWI	unique well identifier
$ZnCO_3$	zinc carbonate

Appendix 9 References

General ERCB Documents

Directive 019: Compliance Assurance
Directive 051: Injection and Disposal Wells—Well Classifications, Logging, and Testing Requirements
Directive 055: Storage Requirements for the Upstream Petroleum Industry
Directive 056: Energy Development Applications and Schedules
Directive 058: *Oilfield Waste Management Requirements for the Upstream Petroleum Industry*
Directive 070: Drilling Waste Disposal Inspection Manual
Informational Letter 98-2: Suspension, Abandonment, Decontamination, and Surface Land Reclamation of Upstream Oil and Gas Facilities
Interim Directive (ID) 99-4: Deposition of Oilfield Waste into Landfills
ID 2000-3: Waste Harmonization
ID 2000-4: An Update to the Requirements for the Appropriate Management of Oilfield Wastes
Oil and Gas Conservation Act
Oil and Gas Conservation Regulations

Alberta Environment and Water Documents

Administrative Guide for Approvals to Protect Surface Water Bodies Under the Water Act. 2001.
Alberta Environment's Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods. 2003.
Alberta Environment Laboratory Data Quality Assurance Policy Procedures, 2004.
Alberta Tier 1 Soil and Groundwater Remediation Guidelines. 2010.
Assessing Drilling Waste Disposal Areas: Compliance Options for Reclamation Certification. 2012.
Alberta User Guide for Waste Managers
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Environmental Protection and Enhancement Act
Policy for Management of Risks at Contaminated Sites in Alberta. 2000.
Salt Contamination Assessment & Remediation Guidelines. 2001.
Soil Monitoring Directive. 2009.
Soil Remediation Guidelines for Barite: Environmental Health and Human Health. 2009.
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Water Act

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Aqueous Phase Samples

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